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THE TRANSATLANTIC RECORD has again been lowered by the new "Deutschland" of the Hamburg-American line, which arrived at Plymouth, England, at 8.20, Aug. 14, having made the voyage in 5 days 11 hours and 45 minutes, at an average speed of 23.32 knots. It is worthy of note that this rate of speed on the route from New York to Queenstown would make the time from Sandy Hook to Daunt's Rock (2,779 miles) less than 5 days, or exactly 4 days 23 hours 6 minutes. The "Kaiser William der Grosse" also lowered her record this week, reaching Cherbourg on Aug. 13 in 5 days 19 hours and 44 minutes from New York, having made an average speed of 22.79 knots. This vessel also holds the record for the longest distance steamed in 24 hours (580 miles). The longest day's run of the "Deutschland" in her last voyage was 552 knots.

THE NEW U. S. WARSHIPS now under construction are reported by Rear-Admiral Hichborn to be in the following stages of completion: Of the battleships, the "Alabama" and the "Wisconsin" are very nearly finished, standing at 98 and 94%, respectively, towards final completion. The "Alabama," building at the Cramp yards, is shortly to have her initial trial trip. The new "Illinois," building at Newport News, is 84% completed. Very little work on the six sheathed protected cruisers now building has been done. The "Denver" is the nearest completed, at 20%, while no work has progressed so far on the "Galveston" and the "Tacoma." The four monitors, "Arkansas," "Connecticut," "Florida" and "Wyoming," are each about half finished. Of the torpedo-boat destroyers, the "Lawrence" and the "McDonough" stand well toward completion, at 96 and 94%. The torpedo boats "Stringham," "Goldsborough," "Bailey," "Barney" and "Stockton" are all set down at over 90% completed. The submarine torpedo boat stands at 85%.

A SIX-MASTED SCHOONER, the first vessel of that rig ever built, was launched on Aug. 14 from the shipyards of Hollis M. Bean, at Camden, Me. The vessel is intended for the coal carrying trade and will have a capacity of 5,000 tons on a draught of 24 ft. Her length on top is 345 ft., beam 48 ft. 6 ins. and depth of hold 26 ft. A crew of 14 men will be required. A 30-HP. engine is provided to hoist the sails, raise the anchor and operate the pumps. The ship is fitted with electric bells, steam heat, baths and a telephone line, so arranged that the captain can communicate with all parts of the ship from the cabin.

THE MOTOR CARRIAGE STAGE LINE now operated by the Fifth Ave. Coach Co., in New York city, will be extended, permission to do this having been obtained from the State Railroad Commission. The permit obtained from the commission gives the company the privilege of prolonging its Fifth Ave. route, which now ends at 89th St., to 135th St., and of establishing a new route from Fifth Ave. along 57th St. to Broadway, up Broadway to 72d St., thence westerly to Central Park; and still another from Fifth Ave. along 110th St. to Cathedral Parkway, to Riverside Drive, and along Riverside Drive, joining the Broadway extension by way of 72d St. The vehicles to be used will have both inside and outside seats and will accommodate 22 passengers. They will be operated by electric power.

BIDS FOR THE ARMOR PLATE for the eight battleships, six armored cruisers and three protected cruisers, authorized by the last two sessions of Congress, were opened on Aug. 10. The armor advertised for aggregates 35,950 tons and constitutes the largest item of its character ever opened to competition by the navy department. The Carnegie and Bethlehem steel companies, which have heretofore monopolized the production of armor plate for the use of the government, had a rival in the Midvale Steel Co., of Midvale, Pa. These three companies were the only bidders for armor plate, but there were two minor bidders for the bolts and nuts, amounting to 600 tons, which are to be furnished in connection with the armor plate.

The Bethlehem and Carnegie companies each bid for only half the armor to be furnished and their bids were identical in amount, terms of delivery and other features. The Midvale company bid for the entire amount of armor at a price considerably below that of the other companies, and also included in their bid a sliding upward scale for lesser amounts than the total aggregate with the condition, however, that the bid should not be considered unless 20,000 tons or more should be awarded to them. While their bid for the aggregate amount is lower, the period which must elapse before deliveries are to begin is much longer, 26 months, against six months, the time specified by both the Carnegie and Bethlehem companies. This long period asked by the Midvale company before deliveries are to begin doubtless is due to the fact that it would have to construct a plant for the manufacture of armor plate. When it does begin delivery, however, it agrees to furnish 500 tons a month, as against 300 tons by each of the other companies.

The bids of the Carnegie and Bethlehem companies are each for 15,000 tons of face-hardened armor of Class A, that is, armor for battleships and armored cruisers of 5 ins. or more in thickness, at $445 per ton, exclusive of a royalty of $45 per ton, making an aggregate cost to the government of $7,350,000 for 15,000 tons of armor of this class. On the Class B armor for the battleships and armored cruisers, which is face-hardened armor of less than 5 inches in thickness, and of which 3,800 tons are to be furnished, each bid at the rate of $400 per ton, exclusive of a royalty amounting to $11.20 per ton, making an aggregate bid of $1,562,560 for this class of armor. For Class C armor, which includes the diagonal armor, bulkhead plates, etc., not face-hardened, of which 1,150 tons are to be furnished, the bid also was $400 in each instance, or an aggregate of $460,000 for the armor of this class. The bid for 600 tons of bolts and nuts also was $400 per ton in each instance. Each company explained that its bid must be considered as a whole, and if awarded the contract under it Krupp armor would be furnished.

The bid of the Midvale Steel Co. was a flat bid to furnish the total of 31,000 tons of Class A armor at $438 a ton, an aggregate of $13,078,000, with no royalty charge to the Government. The upward scale for less than the aggregate amount is as follows: 25,000 tons at $440, 20,000 tons at $442, 15,000 tons at $454, 10,000 tons at $466, 5,000 tons at $500, 2,500 tons at $530. The company makes a conditional bid for Class B armor at the rate of $380 per ton, provided it is awarded 20,000 tons or more of Class A armor, and further states that no award of less than 20,000 tons will be considered. It makes a flat bid of $327 per ton for the 600 tons of bolts and nuts. The Navy Department has rejected all the bids.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at South Raub, Ind., on the line of the Chicago, Indianapolis & Louisville Ry., on Aug. 7. A passenger train, running into an open switch, collided with a freight train standing on a siding. The accident is thought to have been due to the negligence of the switchman. Five people were killed and nine were seriously injured.

THE TORPEDO-BOAT DESTROYER, "Framee," of the French fleet collided with the battleship "Brenmes" during manoeuvers off Cape St. Vincent on Aug. 11. The "Framee" sank immediately. Details thus far received are very meager, but it is believed that no fewer than 50 men were lost. The "Framee" was of 313 tons displacement and was a recent addition to the French navy.

AN EXTENSIVE FIRE was discovered in the hold of the White Star steamer "Cymric" on Aug. 5, when 19 hours out from Liverpool on the way to New York. The fire started in damp straw packed in among crates of pottery. Near by the crates of pottery were hogsheads of chlorate of sodium, which, when heated, gave off dense fumes of chlorine. Many of the men and officers were asphyxiated by the gas. The fire was finally subdued by turning steam into the hold.

THE MOSCOW, RUSSIA, WATER-WORKS are to be enlarged and improved at a cost of about $7,000,000, according to a report made by U. S. Consul Smith, at Moscow. The population of this city is increasing rapidly, and on that account the water-supply question has become a serious matter, requiring immediate attention. The loan was granted in consequence of a water famine, which occurred in May and lasted about five days, through a breakage of the main supply pipe at the connections near the water-works. Foreign manufacturers are invited to make bids for contracts in supplying machinery, etc.

PNEUMATIC TUBE POSTAL SERVICE will be made the subject of a careful investigation by the U. S. Post Office Department. On Aug. 13 the Postmaster-General issued an order directing a general investigation as to the cost of construction, operation, and utility of all pneumatic tube systems for transmission of mails, and including all facts bearing upon their use. This investigation is in accordance with the requirements of the last Postal Appropriation act, and is designed to enable Congress to determine whether the pneumatic tube service should be owned, leased, extended or discontinued by the government, and also to determine the cost at which the government may acquire existing plants or necessary patents. There is an appropriation of $10,000 for the investigation, which will be conducted in a few of the principal cities of the country, including probably New York, Chicago, Boston, Philadelphia, St. Louis, San Francisco and New Orleans. The cities will be decided on later, as will the names of the general committee which will direct the investigation. In each of the cities to be selected the postmaster, assisted by the superintendent of the railway mail service in whose division the city is, will proceed at once to a careful investigation as to the necessity for a pneumatic tube mail service, or for extension to any existing service. When the local committee is ready to report, a general committee of experienced postal officials, representing the department, will make a thorough review of the investigation and of the report, and the two committees will make a full joint report to the department. The joint committee in each case will consult, and, if necessary, employ expert civil and mechanical engineers to assist in the work.

THE CANAL LOCK AT BRIDGEPORT, ILL., built for the Illinois & Michigan Canal by the Chicago Sanitary District, has been an expensive piece of work. This was owing, according to published reports, to the work being done by day labor, instead of by contract, some of the Drainage Trustees sending numbers of men with instructions to the foreman to put them at work. There were 2,193 men on the pay roll, and the work was carried on by three 8-hour shifts, but not more than 500 men were at work on any one shift, and even with this number the men were in each other's way, while at night very little effective work was done. Laborers are said to have been employed, and paid, as skilled workmen. The following is a statement by Mr. Isham Randolph, Chief Engineer of the Sanitary District, as published in the Chicago "Tribune":

> There is no doubt that the lock cost too much. Too many men were employed. It is absolutely true that my estimate on the cost of constructing the lock was $25,000, and that the lock cost $66,000. The exact cost was $66,018.22. The cost of labor was $39,721.19. I do not care to say how much money was wasted. I cannot say how many men should have been employed. The Drainage Trustees secured positions for their proteges while I was absent from the city.

ZION CITY is a new model industrial city projected by Dr. John Alexander Dowie, head of the Christian Catholic Church, and several related institutions, including the Zion Land & Investment Association. The site selected for this city is an undulating tract of land in the northeastern part of Illinois, half way between Chicago and Milwaukee, and about six miles north of Waukegan, Ill. It has an area of about 10 sq. miles, and a frontage of 2½ miles on Lake Michigan. A complete topographic survey of this area was completed in May, and the land is now being laid out in divisions and subdivisions. Complete water supply, sewerage, lighting and rapid transit systems will be laid out on a basis of an assumed population of 200,000. All pipes, conduits, sewers, etc., will be laid in broad alleys between the main streets. The water supply will probably be taken from wells until the growth of population requires a greater supply, which will then probably be drawn from the lake. A sewage disposal system will be projected later on. The first industrial plant to be established will be for the manufacture of fine laces, employing about 100 operatives to begin with. The plans are now being prepared, and when the buildings are completed the entire machinery equipment of a large lace-making establishment in England will be brought over and installed. The arrangements for this have already been completed. About 80 acres have been set apart for this industry alone. The buildings will be of common brick, with pressed brick fronts, and will be 112 × 600 ft. in plan, to which additional wings of similar dimensions may be added as required. They will be two stories high, except the "dressing rooms" for the lace curtain factory, which will be three stories high. The roof will be of a low flat gable type, carried by steel roof trusses. Construction work on the drainage, water supply, factory and dwellings will be commenced during the early autumn. The design and supervision of all this work is in the hands of Mr. Burton J. Ashley, Chief Engineer, whose headquarters are at 1300 Michigan Boulevard, Chicago, Ill.

THE BRIDGE WORK OF THE PITTSBURG, BESSEMER & LAKE ERIE AND UNION RAILWAYS.

(With two-page plate.)

The Pittsburg, Bessemer & Lake Erie R. R., as many of our readers will recall, is a railway which was completed a couple of years ago to carry iron ore from Lake Erie to the Carnegie furnaces at Pittsburg, Pa., at the lowest possible cost. It was formed by the purchase of the Pittsburg, Shenango & Lake Erie R. R., and its extension from Butler, Pa., to Bessemer, Pa., where it connected with the Union R. R., newly built to handle the freight between the three large plants of the Carnegie Steel Co., known, respectively, as the Edgar Thomson Steel Works, the Homestead Steel Works and the Duquesne Steel Works. One of the features of the new construction, which comprised the Butler-Bessemer extension and the Union R. R., was the large amount of bridge and viaduct work. This work comprised in round figures the erection of 22,000 tons of steel in the form of single and double track bridges and viaducts, all of which was done by the Keystone Bridge Works of the Carnegie Steel Co.

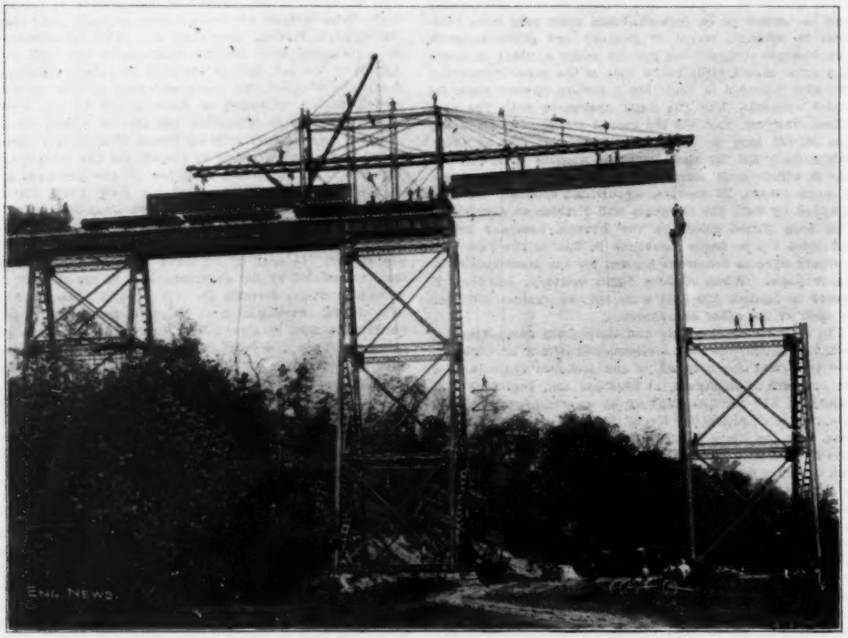


FIG. 1.—VIEW OF SPECIAL STEEL THROUGH TRAVELER ERECTING BULL CREEK VIADUCT, P., B. & L. E. R. R.
Emil Swensson, M. Am. Soc. C. E., Pittsburg, Pa., Designer.
Keystone Bridge Works, Pittsburg, Pa., Builders.

While the bulk of this work contained few purely structural features that will not be found in first-class railway bridge and viaduct work elsewhere, there were some details and features of unusual novelty which are worth particular description. The work had also to be performed to meet a large number of varied and new conditions. It was the first bridge work constructed for carrying complete trains of 160,000-lbs. capacity steel cars. Two large rivers had to be crossed, one of which bore annually a traffic amounting to some 5,000,000 tons carried by 17,000 craft. In addition, many of the structures were built through villages and manufacturing plants, and over about 50 railway lines handling some 25,000,000 tons of traffic annually, none of which could be interfered with.

Pittsburg, Bessemer & Lake Erie R. R. Work.

The bridges and viaducts built for the Pittsburg, Bessemer & Lake Erie R. R. extension from Butler to Bessemer, Pa., were all single track structures and comprised: (1) Three viaducts over Connoguenessing Creek, 180 tons; (2) viaduct over Western Pennsylvania R. R., at Butler, Pa., 640 tons; (3) viaduct crossing Pittsburg & Western Ry., 400 tons; (4) viaduct over Thorn Creek, 525 tons; (5) three viaducts over small streams, 960 tons; (6) viaduct over Bull Creek, 1,500 tons; (7) viaduct over a small creek, 260 tons; (8) two viaducts over small streams, 440 tons; (9) approach to Allegheny River Bridge, 1,140 tons; (10) Allegheny River Bridge, consisting of three 350-ft. deck spans, one 520-ft. deck span, one 210-ft. deck span, and one 25-ft. plate girder span, weighing in all 2,750 tons; (11) Milltown viaduct, 350 tons; (12) Plum Creek viaduct, 740 tons; (13) Thomson Run, two plate girder bridges, 140 tons; (14) viaduct through Turtle Creek Borough, 1,215 tons, and (15) viaduct through East Pittsburg Borough, 625 tons.

The country traversed by the railway was very rough and broken, and the sites of many of the viaducts could hardly be reached by teams. The total length of these viaducts was nearly three miles, and the time for doing the work was exceedingly short. It will be seen that with these governing conditions the problem of the erection of the structures was one that had to be solved at the outset. The most time saving, as well as the most money saving method of erection being necessary, it was decided to erect all the viaducts from off the rail; that is, by means of a specially designed traveler which permitted the material to be taken directly from the railway car track of the traveler by the rear jib, trolleyed through the traveler, and erected by the front jib. This necessitated not only that the material should be shipped in the exact order in which it was wanted in the field, but also that the details should be so designed that this method of erection could be carried on readily and effectively.

To understand the difficulty of the last problem we need only to note that in addition to the regular tower and girder construction usual to all viaduct work, there were numerous instances of special construction to meet special conditions. These comprised deck and through truss spans; deck and through plate girder spans; rocker bents; railway crossings with sharp skews; highway and street crossings, both square and skew; variations in the heights of towers from 15 ft. to 120 ft., making towers of three stories; and variations in the spacing of column bents to suit the street crossings.

The general construction and appearance of the special traveler are shown by Figs. 1 and 2, Fig. 1 being a view of the traveler at work erecting the Bull Creek viaduct, 1,400 ft. long and 145 ft. high. It consists essentially of a steel trestle tower, 40 ft. high, 11 ft. wide and 50 ft. long, mounted on a special platform car. This tower supported a front and rear jib whose horizontal lower chords were continuous through the tower and served to carry a trolley carriage. The forward jib projected 90 ft. beyond the tower, and the rear jib projected 45 ft. behind it, making the total length of the trolley track 185 ft. The rails of the trolley tracks were spaced 7 ft. apart c. to c., and the trolley carriage had a capacity of one 80-ft. plate girder, or a load of 160½ tons on each track. Besides the trolley carriage proper there were mounted on the same track four 10-ton differential chain hoists for unloading material from the cars and carrying it forward. Finally there were ten sheaves spaced at regular intervals on the outsides of the chords of the forward jib, five on each side.

The view, Fig. 1, shows the trolley carriage engaged in supporting a bent of the tower which is being erected, while two of the chain hoists hold the 80-ft. girder ready to lower into its position spanning the interval between the towers. Meanwhile the other two chain hoists are engaged at the rear of the traveler in picking up the second girder of the same span, preparatory to moving it

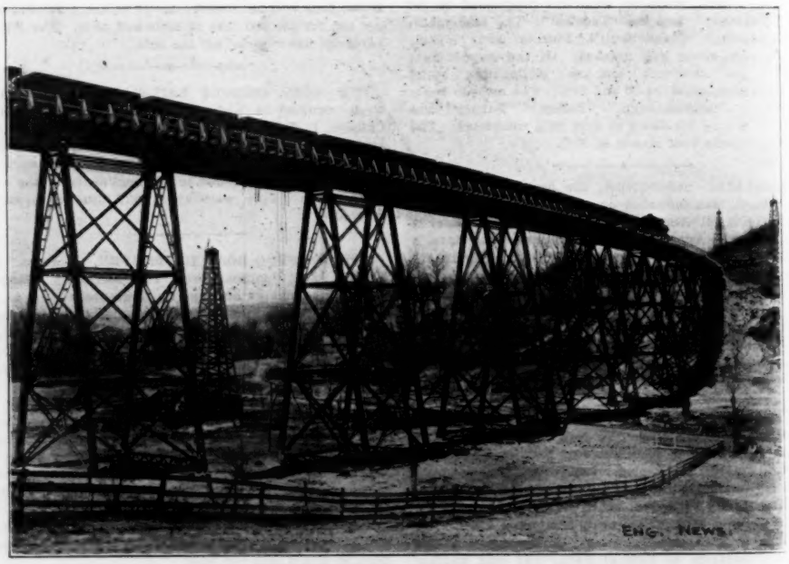


FIG. 3.—VIEW OF BULL CREEK VIADUCT, 1,400 FT. LONG AND 145 FT. HIGH; P., B. & L. E. R. R.

ward into place. Indeed, the object and operation of the traveler are illustrated in all respects ch better by this view than can be done by any unt of description.

The traveler was not only so constructed that it ld be moved from viaduct to viaduct over the road, but it was possible to dismantle it, to through tunnels, of which there were two on road, and then to re-erect it. The traveler was ved by its own engines and tackle for the short ances necessary when it was at work, but the

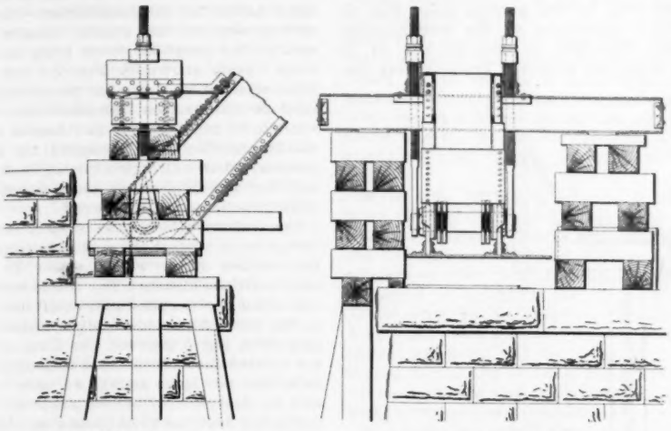


FIG. 6.—DEVICE FOR LOWERING BRIDGE SPANS FROM FALSEWORKS ONTO ABUTMENTS.

movement between viaducts was made by locomotives.

Regarding the structural features proper of the viaduct work, it is not necessary to say much besides the general description of its character already given. The largest of the several viaducts was that known as the Bull Creek viaduct, upon which the traveler is shown working in Fig. 1. Fig. 3 is a more comprehensive view of the same structure, which also possesses a considerable degree of interest for the manner in which it illustrates the industries of western Pennsylvania. It will be noticed that there are shown within the territory covered by the view four different oil wells in operation, while a train of 50-ton pressed steel ore cars is crossing the viaduct itself. The viaduct consists of alternate 80-ft. and 40-ft. spans carried by trestle towers, the highest of which is 114 ft. from the top of the masonry column piers to the base of the girder seats.

The largest structure of any kind was the Allegheny River Bridge, which consisted of three 350-ft. deck spans, one 320-ft. deck span, one 210-ft. deck span and one 25-ft. plate girder span weighing 2,750 tons, besides a viaduct approach comprising 1,140 tons more of steelwork. The bridge spans proper of this structure were erected in the usual manner, with a falsework and wooden through traveler, proceeding from the west side of the river for the four largest spans. This required all the material for these four spans to be shipped from the bridge works at Pittsburg over the Allegheny Valley and Western Pennsylvania railways to the bridge site. The 210-ft. span crossing the Allegheny Valley Ry., at the east end of the bridge, was erected directly from that place. At this point it may be noted that the construction of the road from Butler toward Pittsburg made it necessary to ship all the viaduct material to Butler, and then bring it over the newly-constructed line, to be erected as the successive structures were approached.

Returning to the Allegheny River Bridge work, it should be noted that the most interesting features about this bridge are, first, that the traveler and falsework were designed with the intention of using them also for the Union R. R. bridge over the Monongahela River, which is described further on. While, however, the Allegheny River Bridge was a single track bridge, the Monongahela River Bridge provided for two tracks, and the spans of the two bridges being of different depths, it was necessary to construct both the traveler and falsework in such a manner that they could be widened or narrowed, lengthened or shortened, as the spans and structures required, with a minimum expenditure of time and money. The second matter of interest is the plan which was adopted to economize in falseworks and height of lifts in erecting the Allegheny River Bridge. Arrangements were made for transporting the material for the second, third and fourth spans over a temporary floor at the level of the lower chord of the span previously erected. This temporary floor was partly supported by the lower chord and partly by rods suspended from the regular floor above. This temporary loading of the structure, of course, required a suitable provision for it in designing the steelwork.

The preliminary provisions made for conducting the erection of the various viaducts and the Allegheny River Bridge, of course, made some extra work in the drawing room, but they justified

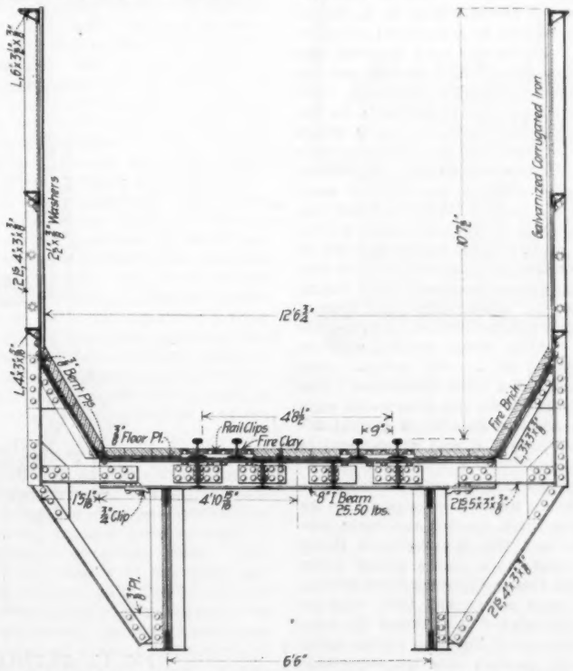


FIG. 9.—DETAILS OF FIREPROOF FLOOR FOR DOUBLE TRACK THROUGH SPANS.

themselves in the extremely short time in which the structures were constructed, both in the shop and in the field. Indeed, the erection as planned was carried out without a single mishap, and at a greatly reduced cost for erection.

Union R. R. Work.

The Union R. R. handles the freight between and connects the three large plants of the Carnegie Steel Co. Ltd., namely, the Edgar Thomson Steel Works, the Homestead Steel Works and the Duquesne Steel Works. As already stated, this road forms the terminal line of the Pittsburg, Bessemer & Lake Erie R. R., which connects with it near the Bessemer Station of the Pennsylvania R. R. Briefly summarized, the bridge and viaduct work done for the Union R. R. comprised the following structures: (1) A double track through square truss span, 182 ft. long, over the Pennsylvania R. R. main line at Bessemer, Pa., weight 370 tons (see A, Fig. 4); (2) a double track viaduct from this span crossing Turtle Creek, each track being on a different grade, one being for the Union R. R. main line and the other for a siding down into the yards of the Edgar Thomson Steel Works, 1,400 tons (see B, Fig. 4); (3) a double track through plate girder structure over the Baltimore & Ohio R. R., 276 tons (see C, Fig. 4); (4) a single track viaduct approach, on the north, to the Monongahela River Bridge, crossing the Baltimore & Ohio R. R., and the Pittsburg, McKeesport & Youghiogheny R. R., 375 tons (see D, Fig. 5); (5) a hot metal viaduct from the Edgar Thomson Furnaces, crossing Turtle Creek and connecting with the Monongahela River Bridge, 1,200 tons (see E, Fig. 5); (6) a double track and provision for third track, Monongahela River Bridge, consisting of one 400-ft. through span, one 250-ft. through span, three 180-ft. deck spans, and one 150-ft. deck span, including metal floor for fireproofing one track, 3,400 tons (See F, Fig. 5); (7) a double track viaduct approach to the Monongahela River Bridge on the south, including metal floor for fireproofing, leading toward Homestead Steel Works, 930 tons (see H, Fig. 5); (8) a single track viaduct, including steel floor for fireproofing, leading off the south approach viaduct toward the Duquesne Steel Works, 610 tons (see H, Fig. 5); (9) a single track through span, 126 ft. long, over the P., V. & C. R. R. (Pennsylvania), Turtle Creek Branch, adjoining above viaduct on line toward Duquesne Steel Works, including metal flooring for fireproofing, 160 tons (see J, Fig. 5); (10) two double track through spans, each 190 ft. long, over the main line of the P., V. & C. R. R., on Monongahela Division of the Pennsylvania R. R. on Union R. R. line, leading toward the Homestead Steel Works, including metal floor for fireproofing, 1,070 tons (see K, Fig. 5); and (11) a single track through span, 252 ft. long, over the main line of the P., V. & C. R. R., leading toward the Homestead Steel Works, including metal floor for fireproofing, 440 tons (see L, Fig. 5).

Adding together the individual weights of the structures just enumerated, we have a total tonnage of 10,231 tons of bridge work constructed for the Union R. R., besides the total of 11,865 tons already described as being built for the Pittsburg, Bessemer & Lake Erie R. R. Many of the details of this work call for no particular mention, but there are some others which are novel, and these are illustrated on our two-page plate and in the accompanying cuts.

Taking up the bridge structures of the Union R. R., in the order in which they have been enumerated, we come first to the 182-ft. double track through span carrying it over the four tracks of the Pennsylvania R. R., main line, near Bessemer. The location and general character of this structure is shown by the plan Fig. 4. It was a pin-connected square truss, and its chief interest structurally lay in the limited headroom available, owing to the fact that the difference in the grades of the crossing lines which was adopted was the minimum practicable distance, and to the fact that the traffic on the Pennsylvania R. R. tracks below was not allowed to be obstructed either in amount or speed. Trains are very frequent and passenger trains ran at very high speeds, and the railway company refused to slow its trains. The location of the crossing, too, it will also be observed from Fig. 4, was on a skew at a sharp curve. For these reasons, and also because there was no headroom for falseworks under the bridge at its proper level, it became necessary to erect the bridge above its proper level; to build the falseworks so as to form regular tunnels over the Pennsylvania R. R. tracks, spreading some of them for the bents, and to construct a tight roof so as to prevent anything whatever from falling onto the trains passing underneath. The floor of the bridge was then made as shallow as first-class construction and rigidity would permit, and the steelwork was erected at a level several feet higher than its final level when completed. The lowering of the bridge from the falseworks onto the masonry was accomplished by a special device which is shown by Fig. 6, and which requires no further explanation.

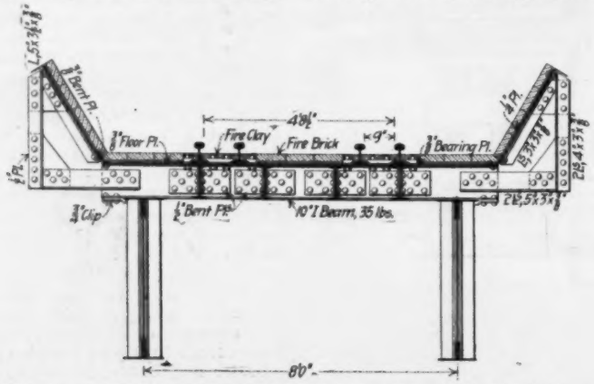


FIG. 10. DETAILS OF FIREPROOF FLOOR FOR SINGLE TRACK VIADUCT.

The double track viaduct running off from the 182-ft. span was of an unusual construction. As already stated, one track carried the main line of the railway toward the Monongahela River Bridge, and the other track was a siding down into the yards of the Edgar Thomson Steel Works. Both tracks were on a curve, and both were on different grades. The plan, Fig. 4, shows the relative levels and locations of the two tracks quite clearly. The whole viaduct was an especially complicated piece of work, owing to the curvature, the skew crossings of railways and streets, and the irregular spacing of columns and bents; and the complications were materially increased at that portion of the viaduct which crossed Turtle Creek on a sharp skew. At this crossing the main line passes over on a deck, while the low grade track is three-quarters deck, with the floor beams and stringers varying in height.

About the only feature of the double track through plate girder span crossing the Baltimore & Ohio R. R. (C, Fig. 5) to which attention needs to be called especially is the simplicity effected by making the skew structure with square ends and spacing the intermediate column skew bent parallel with the tracks of the railway. It may be noted here also that a similar arrangement was employed at the Pittsburg, Bessemer & Lake Erie R. R., crossing of the Pittsburg & Western R. R., which has been previously mentioned, and at the crossing of the Union R. R. yard track by the main line or high level viaduct just described (B, Fig. 4).

As will be seen by the general plan, Fig. 5, there are two approaches to the Monongahela River Bridge. The first of these (D, Fig. 5) is the regular main line approach crossing over the Baltimore & Ohio and the Pittsburg, McKeesport & Youghiogheny railways. Its construction calls for no particular description except to note that the special steel traveler previously described, Figs. 1 and 2, was employed in its erection. The second approach to the bridge from the north is the viaduct (E, Fig. 5) for the special hot metal line, the purpose and construction of which are explained further on. This viaduct was made somewhat complicated in construction owing to its location on a 20° reverse curve, with several overhead crossings of streets, railway tracks, etc.

The structure crossing the Monongahela River proper is shown in general plan and elevation at F, Fig. 5. As will be seen, it consists of six pin-connected truss spans, the longest of which is 400 ft., and is located at the north end. Structurally this bridge is of considerable interest, (1) because the spans are designed with two trusses for a double track, and with a provision for a third truss and third track, to be built at some future time; and (2) because of the necessity of fireproofing the steelwork along the hot metal route. From Fig. 5, F, it will be seen that the new third truss will be added to the upstream side of the bridge. To provide for the additional construction hereafter, the present upstream truss is made heavier than the downstream truss, but is otherwise the same except for the fireproofing. The transverse arrangement of the present trusses and tracks and of the proposed third truss and tracks are quite clearly shown by Fig. 7. The trusses are pin-connected with eye-bar tension members and built-up compression members. The floor system consists of plate girder floor beams at the panel points carrying four stringers for the through trusses and two stringers for the deck trusses. Altogether the details are those common to first-class pin-connected trusswork.

The features which were of chief interest in the bridge work were those arising in connection with the erection of the 400-ft. span. To understand the conditions clearly a few words need to be said regarding the peculiar nature of the river traffic at the point where the bridge crosses. It will be seen from Fig. 5 that the two locks of Dam No. 3 are located just above the 400-ft. span. As these locks are not large enough to pass a steamboat, and its fleet of coal barges made up as between dams, the fleet has to be broken up above the dam and both locks used for passing it. The coal barges are permitted upon leaving the lock to drift with the current until the steamboat can overtake and collect them. This collection takes place nearly under the 400-ft. span, and very often at the same time that other steamboats with their loads of empty barges are striving to get upstream through the locks. The result of all this is that there is at times a great deal of confusion and excitement at this point, and the falseworks had to be designed to provide for unusual contingencies of collision from steamboats and barges.

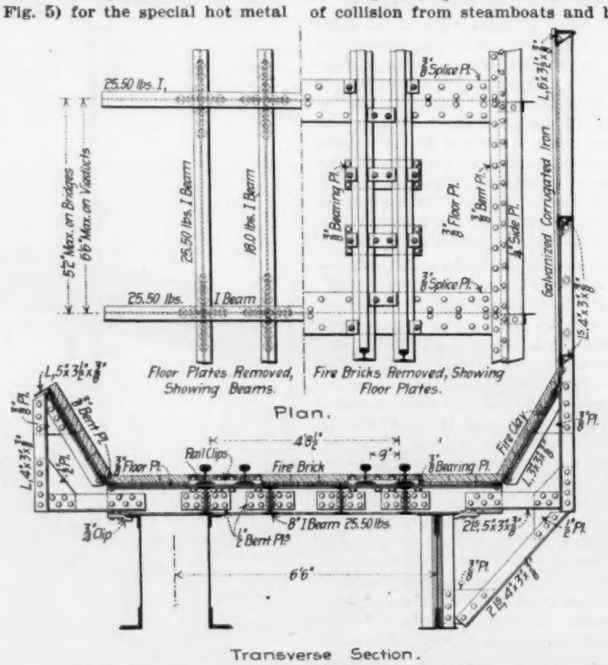


FIG. 11.—DETAILS OF FIREPROOF FLOOR FOR SINGLE TRACK DECK SPAN.

In the first place, a large opening had to be left in the falseworks to permit the passage of the river traffic, and, secondly, this opening had to be protected against the onslaught of the hurrying and conflicting river craft. To accomplish all this the following plan was adopted: The four 90-ft. girders intended for the Union R. R. main line, as well as those for the hot metal route, crossing the P., McK. & Y. Ry. next to the land pier of the large span, after first being erected in place to

permit the steel traveler to pass onto the first part of the falsework for the large span, were taken up by this traveler, and carried forward, and used for spanning the opening in the falsework provided for the passage of boats. Protection pilings were put on either side of this opening, and carried out to both sides of the span in fan shape, ending up with clusters of piles, to facilitate the entrance of boats. These protection pilings were braced with planking and finally lined with several rows of 100-lb. steel rails, to save the falsework from any harm. The details of this construction and the general details of the falsework proper are shown by Fig. 8. Although some anxious moments were passed until this large span was connected up, nothing very serious happened. The large through traveler used on the Allegheny River Bridge, of the P., B. and L. E. line was used here, as well as for the remaining part of the Monongahela River Bridge proper, the erection of which does not offer anything special. It is only to be added that the first span erected was the 150-ft. span, and the material for all the other spans, including the large span, was carried out from that side over the spans already erected, the large span being erected last. It is an interesting fact, that from the top of the traveler when on this bridge, one had a birds-eye view, it is said, of the largest moving tonnage in the world.

Turning now to the system of viaducts at the south end of the bridge, the first structure met is the south approach to the river spans from the Homestead Steel Works, with the branch approach from the Duquesne Steel Works. There is very little unusual in any of this viaduct work proper except, perhaps, the complicated bents at the junction of the two viaducts, and of course the fireproof floor system. It may be noted in passing that the 125-ft. bridge on the Duquesne line was erected above its normal level and lowered into position by means of the device already described in Fig. 6. The double track crossing of the main line of the Pittsburg, Virginia & Charleston R. R., K, Fig. c., is interesting for the reason that the two spans are in a measure made as only one span—the extreme ends being square, while the opposite ends meet on a skew at the middle—the floor being continuous throughout both. This construction has proved remarkably rigid. The 252-ft. single track span, L, Fig. 5, illustrates a case where, on account of the very sharp skew of the crossing, a square span was adopted as being, on the whole, the most economical.

Altogether the most interesting and novel feature of the bridge and viaduct work for the Union R. R., is undoubtedly the fireproof construction on the hot metal routes, from the Edgar Thomson Steel Works to the Homestead Steel Works, and from the Duquesne Steel Works to the Homestead Steel Works. This route is used for hauling cars carrying ladles of molten metal from one works to the other, and it was absolutely necessary to provide protection for steamboats and other craft in the river, the teams and pedestrians using the streets below, and the railway trains passing underneath. It was also thought necessary to protect the steel in the structures to prevent it being cut by molten metal should some splash over from passing trains of hot metal-laden cars, or should a ladle upset when passing over the structure.

The fireproof construction adopted is shown by Figs. 9 to 11, inclusive. Briefly described, it consists of a trough-shaped floor of fire-brick laid on steel plates, with a high side fencing of galvanized corrugated iron over the through spans. The several sections, Figs. 9 to 11, show the construction in detail. The metal floor carrying the fireproofing weighed about 700 lbs. per lin. ft. of single track, and 1,200 lbs. per lin. ft. of double track, and of course this extra load had to be provided for in designing the steelwork.

As stated at the beginning, this bridge and viaduct work for the two railways named was designed, built and erected by the Keystone Bridge Works, of the Carnegie Steel Co., Mr. Emil Swensson, M. Am. Soc. C. E., Chief Engineer. We are indebted to Mr. Swensson for the information from which this description of the work has been prepared.

MECHANICAL ENGINEERING EXHIBITS AT THE PARIS EXPOSITION.

(Editorial Correspondence.)

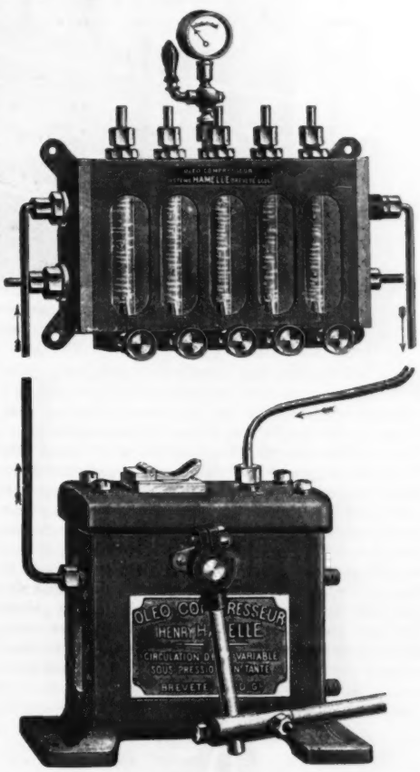
If the question were put, in what department of this Exposition does the United States make the best showing in comparison with other nations, the answer given must be in favor of the department of machine tools. The American machine shop at Vincennes, with the display in the United States section of the machinery exhibit on the Champ de Mars, is a more representative and creditable showing for American industry than can be found anywhere else in the Exposition. There is, of course, a good reason for this. American machine tool makers have been doing a large export business during the past four or five years, and the Exposition furnished a fine opportunity to push their goods still further in this market.

It is true that the exhibits in this department do not appeal to the popular eye. A very small percentage of those who visit Paris to see the Exposition ever go to Vincennes. The daily admissions there average perhaps 5,000 or so, as compared with 200,000 for the main Exposition. There need be no surprise, therefore, if most American visitors to the Exposition go home in entire ignorance of the best thing which the United States has to show here, and the exhibit which more than any other gives the key to American supremacy as a manufacturing nation.

One does not need to spend much time studying the European exhibits here to reach the conclusion that the foreign workman is no mean competitor for American industry to meet. We have heard much of European pauper labor and a great deal of the superior skill and intelligence of the American workman; but he must be indeed prejudiced who can walk anywhere in this great Exposition and fail to see on every hand the evidence of marvellous skill, great artistic ability and a large amount of originality in design on the part of the workers of Europe. France, Germany, Hungary, Sweden, Russia and the other continental nations as well—all tell the same story. Let us give these workmen all the credit that is their rightful due, and fairly acknowledge that in our universal adoption of automatic machinery in America we have to a certain extent lost our skill in handwork. With tools few and crude, in many instances, the European workman fashions things, often at an expense of much time and labor, which, when completed, compel our admiration. The American will find something which will answer the purpose as well or better and will so design it that it can be turned out by rapid machinery and often sold at a profit for less than the cost of the European article. In a word, where the European makes or builds a thing the American manufactures it. It is the American system and not the inferiority of European workmen that is giving the United States its foreign trade in manufactured goods, and nowhere can visible evidence of the American system be better seen in this Exposition than in the department of machine tools.

It must not be imagined, however, that Europeans are wholly ignorant of this. There are no patents on the American system, and the large export trade which American machine tool builders have enjoyed in recent years is good evidence of Europe's appreciation of American ideas. The very extensive and fine display of European machine tools contains evidence as to how closely the makers in America and abroad are following along the same lines. Automatic grinding machines, boring mills, turret lathes, shapers and other machinery which has revolutionized American machine shop practice in the past quarter century are all to be found in the foreign exhibits, and so far as fine finish can go, certainly compel admiration. I believe, however, that the American tools still excel them as a rule in convenience and ease of operation and control. Rapid work and large output, with the minimum cost for attendance, is what the American machine tool builder has ever in mind, and it is not hard to find evidences in the Exposition that many European builders are still content to build machines as their fathers built them, and many European customers are satisfied to buy the machines their fathers bought.

If one turns to the department of Steam Engineering, however, for information as to the relative progressiveness of European and American engineering practice, he must receive impressions quite the reverse of those just set forth. Here it is the Europeans who are displaying progressiveness and the Americans who are sticking to the ruts. Let it be said at once, however, that the American display of steam engines is chiefly conspicuous by its absence. The only stationary steam engine of American design and manufacture in this whole Exposition is the 300-HP. Ball compound in the American machine shop at Vincennes, which drives a Bullock generator, furnishing current to operate the machine tools in the various exhibits. This engine, however, did not begin running until June 27, owing to the fact that its flywheel and the armature of the generator and a few other important parts of its anatomy went astray somewhere on the journey from the United States. Consequently for the first two months or so the American machine shop had the



Positive Oiling Apparatus, with Sight-Feed Distribution.

Made by Henry Hamelle, 19 Quai de Valmy, Paris.

humiliation of being supplied with power by an English (Willans) engine, temporarily installed for the purpose.

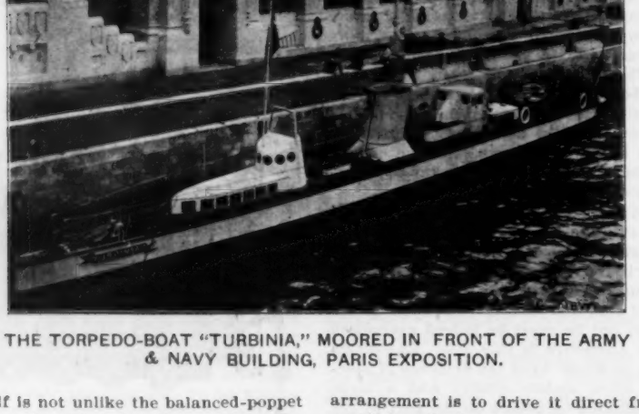
Besides this Ball engine, American steam engine practice is represented here by the large compound steam air-compressors in operation in the Ingersoll-Sergeant and Rand exhibits, by a large vertical triple-expansion Reynolds-Allis engine built by the French Thomson-Houston Co., and shown in the French mechanical exhibit, and last, but not least, by the Worthington high-duty pumping engines, which furnish the water supply for the Exposition, and were built by the French Worthington Co., and by a large vertical Worthington high duty engine, which was built by the Hungarian Worthington Co., and forms the most prominent feature of the Hungarian machinery exhibit.

When this list is compared with the great number of steam engines, many of them of large size, which are in operation in the European exhibits, it will be seen how very small a figure the United States cuts here in this department.

These are the facts. Now, what are the features

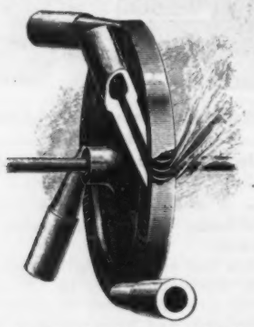
of European steam engine practice that American engineers can study to advantage?

First and most important, without doubt, is the use of poppet valves. While all sorts of valves and valve motions are to be seen on these foreign engines, the poppet valve is used on the majority, and has evidently won its way to high favor here. It is designed and applied in a great variety of ways; but the most common practice is to place it on top of the cylinder in horizontal engines.



THE TORPEDO-BOAT "TURBINIA," MOORED IN FRONT OF THE ARMY & NAVY BUILDING, PARIS EXPOSITION.

The valve itself is not unlike the balanced-poppet throttle valve used on American locomotives. An example which may be taken as typical was shown in the drawings of the Borsig engine, published in Engineering News of June 21, page 405. The advantages of the poppet valve over the slide valve have been often set forth, but it may be worth while to sum them up here. It takes less power to operate, it requires little or no lubrication; it works well with superheated steam; it has very little wear; it remains tight with use, and it can be so operated as to give quick cut-off and release and avoid throttling the steam in the ports. The last particular relates of course more particularly to the valve motion; but it is certain that some of these European poppet-valve engines give



Perspective View of Wheel and Buckets of De Laval Steam Turbine, Showing Nozzles in Position.

fine indicator cards and show remarkably good fuel records in service.

The valve gear on these engines is most frequently operated by a shaft driven by bevel gearing from the engine shaft, and the valves themselves are worked by cams with usually some form of releasing gear on the admission valves. As already remarked, however, there is a great variety in the design of the valve gearing and every range in its complexity, from extreme simplicity to perfect nightmares of rods and levers and pins and latches and links.

At the time of the Chicago Exposition it looked as if practice were setting strongly toward the vertical marine type engine for driving electric generators, and this has proved to be the case in American practice. In Europe, however, the horizontal engine remains in favor, and where saving of ground space is not essential it has evident advantages in accessibility and ease of erection. The objection to the horizontal engine of the side wear on the cylinder is partially obviated by the general use of tail rods. Frequently the air pump is worked off the tail rod, but a more common arrangement is to drive it direct from the main crankpin. Independent air pumps seem to be in less favor in Europe than in the United States.

The shaft governor or flywheel governor, so extensively used on American steam engines, is used on only one or two of the European engines exhibited, and is of course only suited to engines having a valve gear driven by eccentrics. The centrifugal flyball governor in some form is the common type, and it is generally driven by some more positive and safe arrangement than the leather belt drive which is still common practice in the United States on Corliss engines.

The use of forced lubrication devices driven by the engine itself is another noticeable feature on most of these European engines. The oil to be supplied to the various parts is placed in a central reservoir, and is slowly forced from this reservoir by a very small pump. To give this pump a very slow motion it is driven by a toothed wheel, which is turned a few degrees at each stroke of the engine by a ratchet arm attached to some moving part. From the delivery side of this pump small copper pipes lead to each part of the engine where lubrication is desired. In some cases a sight-feed arrangement is used in connection with this positive oiling. The delivery of the oil from the pressure reservoir is to the bottom of a manifold with glass fronts and filled with water. From the top of each compartment of the manifold a copper tube leads and a small cock operated by a milled-head screw enables the flow to any pipe to be adjusted. The flow of the oil as it rises drop by drop through the water can be watched and the rate of flow to each bearing altered to suit its needs. The whole apparatus is very small and compact, and while these little copper worms scattered about over an engine do not improve its appearance, this method of oiling is certainly efficient and economical both of labor and material. It may be noted here that its use is not confined to stationary engines, but it is to be seen on locomotives and marine engines, and is, in fact, applicable to any machine where positive automatic lubrication of several parts is desired.

Three steam turbine makers have exhibits here: The Parsons Co., of Newcastle-on-Tyne, England; the De Laval Co., of Stockholm, Sweden, and Ekermann & Liedbeck, of Stockholm, makers of the Seger turbine.

In all these machines the motive power is a jet of steam at high velocity acting on suitably shaped vanes or buckets attached to a revolving shaft. In the Parsons turbine the steam acts alternately on buckets and on fixed guide vanes, the first attached to a revolving shaft and the second to the interior of the cylinder in which the shaft and buckets revolve. Thus the steam is expanded in successive stages, losing a few pounds in pressure at each stage. By this means the speed of rotation of the Parsons turbine has been reduced to such a point that it can be directly connected to a generator or even to a screw propeller for marine propulsion. The Parsons exhibit on the Champ de Mars includes a fair-sized generating set, which is shown in operation. The famous "Turbinia" is moored in the Seine by the Army and Navy building, and a view of her is shown in the accompanying cut. She has three shafts, with three propellers on each shaft, and each shaft is driven by a steam turbine mounted directly upon it. The "Turbinia" has attained a speed of 34½ knots and her steam consumption is about 14½ lbs. per I. HP. per hour.

The de Laval turbine is very different from the Parsons, having only a single set of buckets formed in the rim of a steel disk. These are acted upon by jets of steam issuing from a series of nozzles, the whole arrangement being not unlike a Pelton type water-wheel. The speed attained is enormous, the number of revolutions being from 7,500 to 30,000 per minute, and the rim speed from 550 to 1,300 ft. per second. To reduce this speed to a practical figure a pair of miter-gears with very broad faces and short teeth is used; and there is no other instance in the whole field of mechanical engineering of the successful use of gearing at such enormous speeds. A pair of phosphor-bronze gears are shown which were in daily use transmitting about 12 HP. from February, 1883, to February, 1900, and are estimated to have made over 20,000,000,000 revolutions in that time, yet the wear on them is inappreciable. The de Laval turbine is chiefly in use for driving electric generators, centrifugal pumps for high heads and blowing fans. As there is no compounding, as in the Parsons turbine, a greater steam consumption might be expected, but some of the tests published by the company show an economy almost or quite as good as that of the Parsons. For either of these turbines a steam economy is claimed in daily service equal to that obtained by first-class triple-expansion steam engines.

The Seger turbine is a machine of recent development. It is similar in type to de Laval's, but

Interior of Seger Steam Turbine.

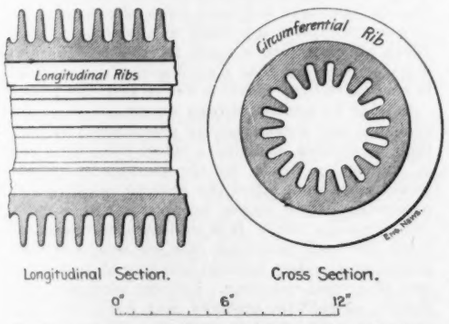
employs two revolving disks instead of one, on which the steam acts successively. It was expected in this way to obtain a higher economy than that shown by the de Laval turbine; but a test of which a report is published, made by two professors of the Stockholm Polytechnic Institute last April on a 60-HP. machine, shows a steam consumption of 10.5 kg. per brake horse power per hour. The rotative speed of this turbine,

however, is much lower than that of the de Laval turbine.

An advantage of the steam turbine worth consideration is that it requires no internal lubrication and hence lends itself well to work with surface condensation, where it is desired to use the water over and over again, as in marine practice. It also works well with superheated steam; and European makers and users of steam engines are fully awake to advantages of superheating and are doing a good deal in this direction.

Two types of superheaters are shown here. A bent-pipe system, designed for use with direct heat from an independent fire is to be seen in the exhibit of Stork Bros., of Holland. The other is the Schwoerer superheater, which utilizes the heat in the gases after leaving the boilers, and consists of a system of cast-iron pipes having longitudinal ribs on the inside and circumferential ribs on the outside. Sections are shown herewith. The job of casting the pipes for these superheaters must be a very difficult one, and it is doubtful whether the ribbing of the pipes, either inside or outside, gives any real practical advantage. There might be some gain if the pipe surfaces remained clean, but this they will never do. The outside corrugations especially are sure to get filled up with soot and ashes, and it is practically impossible to keep them clean as might be done if the pipes were smooth. As for the inside ribs, the steam takes up heat so much more readily than the hot gases impart it, and the outside of the pipe will be at best so coated with soot and flue dust, even if left smooth, that it is doubtful whether the inside ribs are of any real benefit.

Of the boiler exhibits, the most interesting is the array of boilers at work in the large power house which supplies steam to the engines in the Mechanical exhibit. There are batteries of boilers here from a dozen different makers, and while there are one or two examples of internally-fired shell boilers, the water-tube type is the common one. Certainly the French have reason to be



Sections of Pipe Used in Schwoerer Superheater.

proud of the record which their inventors and manufacturers of water-tube boilers have made. The Belleville boiler, which was one of the pioneers in this field, has been furnished to the navies of nine different nations, and up to the close of last year the total of Belleville boilers in marine service amounted to 1,854,720 HP. England alone has fitted 57 naval vessels with Belleville boilers since 1893, the total aggregating nearly 900,000 HP. Now, however, the Niclausse boiler appears to be taking the lead, and its adoption for the new battleships of the American navy makes it of especial interest to Americans. The Niclausse boiler is being pushed for stationary work as well as marine service, and a large battery of this make is at work in the power house.

Mechanical stokers are to be seen occasionally, but are evidently of less importance over here where labor is so cheap than in the United States. A number of the boilers in the power house are fitted with mechanical stokers, and also with automatic ash-handling apparatus, but for some reason or other this was out of use more or less of the time.

A very interesting class of exhibits are the devices for indicating the water level in the boiler. A variety of gage glasses are in use and it is common to apply a pair of gage glasses to each boiler. To make evident the height of water in the glass, one plan is to make the back of the glass corrugated and silvered, and this is done in such a way that the water in the glass appears as a black column on a shining background. Another plan is to put a red or black line behind the water column. This is magnified where the water covers it to double or treble its real size, and makes the height of the water apparent at a glance. Still another plan is to place a colored float in the glass tube. One battery of boilers in the power house has in addition to the water glasses a dial on top of the boiler, and a moving finger connected to an internal float indicates the height of the water. This is apparently the best water-height recording device exhibited. The dial is so large that the position of the finger can be seen from any part of the firing space; and the perpetual movement of the finger back and forth when the boiler is steaming gives constant assurance that the apparatus is in good working order. I see no reason why such a device should not be more reliable than a gage glass, and it is free from the many dangers and difficulties which attend the use of gage glasses with high-pressure steam. In this connection it may be remarked that several devices are to be seen here for the protection of water tenders from injury by the bursting of gage glasses. Brass shields are, of course, common and generally increase the difficulty of reading the water level in the glass. In several cases the gage glass is enclosed within a shield of heavy plate glass of triangular shape, and in some cases wire-glass is used for this outer shield. Both these plans are objectionable, however, for should the gage-glass burst, the plate-glass is very likely to break with the sudden heating and strains. As for the wire-glass shields, some of them here have cracked merely from the heating and cooling of ordinary use.

It may be noted here that one very excellent practice sometimes found in foreign boiler rooms is to relieve the firemen of all responsibility for the height of the water in the boilers and place this duty in the hands of a special water tender. A gallery is often run along the fronts of the boilers close to the gage-glasses to enable this work to be readily and certainly done.

In the smaller class of steam engines at the Exposition, a type which is evidently a great favorite is the "Locomobile," as it is called in France, or semi-portable, as it is termed in the United States, with the engine mounted on top of the boiler. Such machines, in moderate sizes, mounted on skids are common enough at home; but here in Europe they seem to be in favor in astonishingly large sizes. One of them exhibited by R. Wolf, of Magdeburg-Buckau, is a compound condensing machine of 200 HP. with direct-connected air pump, and it is mounted on top of an internally-fired shell boiler about 7 ft. in diameter. To call such an arrangement either "mobile" or portable, seems pretty far fetched to an American, for it would be much more easily moved from place to place if the boiler and engine were entirely separate. In fact, the chief claim made for this type of engine, and apparently the only excuse for building such large sizes of this type, is that a high economy is secured through the avoidance of all loss of heat between boiler and engine, and through the partial jacketing of the cylinder by contact with the boiler. For the Wolf engine above referred to is claimed a steam consumption of 6.2 to 6.8 kg. and a coal consumption of 0.7 to 0.8 kg. per effective horse-power hour, which is certainly a high record.

The greatest curiosity in steam engines in the whole Exposition is a vertical torpedo-boat triple-expansion engine, which bears the name of the famous firm of Schneider & Co., of Creusot, France, and is shown in the French machinery exhibit. The peculiar thing about this engine is that the valves are moved by hydraulic pressure alone. Each valve rod is continued through a hydraulic cylinder with a double-acting piston, and the valve is moved by forcing oil in above or below the piston. To force in this oil and move the valve in proper unison with the movement of the engine, there are three hydraulic cylinders arranged radially around the main shaft, and an eccentric on the shaft moves pistons in these cylinders. Copper pipes go from the two ends of each of these cylinders to the corresponding ends of one of the valve-operating cylinders. Thus, if everything remains perfectly tight, the valve must move in harmony with the movement of the pistons driven by the eccentric.

For weeks this engine has been a source of attraction to engineers visiting the Exposition, and the puzzle has been whether it could ever be persuaded to work. It was not set up until June, and during the last week of that month the workmen were daily endeavoring to get the valves in position for the engine to turn over under her own steam. They had not succeeded at the end of the month, and whether they have had better luck since, the writer is not informed.

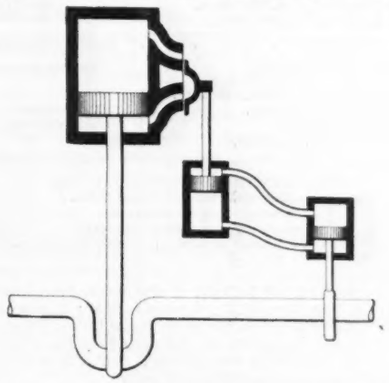


Diagram Illustrating Operation of Hydraulic Valve Gear; Schneider Steam Engine.

The scheme might be made to work, possibly on a very slow moving engine, such as a water-pressure engine for example, though even here no advantages can be seen in such an arrangement. This engine, however, is a high-speed torpedo-boat engine, designed for about 350 revolutions per minute. Thus the flow of oil in the small pipes must be reversed 700 times per minute, or nearly 12 times per second, and the sort of water hammer which this will naturally cause can be imagined. Again, even if the engine could be started, the slightest leak in any part of the valve-operating machinery would put one valve out of unison with its fellows. The puzzle is, why so rash an experiment should be set up at a great Exposition before its practicability has been proved.

AN ELECTRIC INDICATING LOG of a new type was recently given a trial on the United States torpedo boat "Porter." It is the invention of Capt. A. N. McGray, of Boston, Mass. It consists of a small propeller trailed after the ship by a long cable containing two insulated conductors. The propeller operates a train of mechanism which periodically closes an electric circuit. An electro-magnet on board the vessel advances the indicating mechanism step by step with the closing of the circuit. The instrument tested registered to twentieths of a mile and is said to have given results correct to one-half of 1% on a trial run of 44 miles.

AN ELECTRIC STEERING GEAR has been patented by Mr. H. W. Buck, and the rights to the same have been transferred to the General Electric Co., of Schenectady, N. Y. A small electric motor drives a countershaft at a constant speed. At the ends of this shaft are electro-magnetic friction-clutches, so designed that only one may be in operation at a given time and that they will move the rudder in opposite directions. From the clutches the motion is transmitted to the rudder by worm-gearing or other non-reversible gearing, so designed that the frictional resistance is great enough to hold the rudder in any position. A series of contacts in the pilot house is connected with another series of contacts near the rudder or other driven part. The circuits are so arranged that when the rudder has moved to a position corresponding to the position of the wheel the circuit through the clutch is broken. To prevent the clutches from sticking they are acted upon continuously by weak differential coils, which, acting in the reverse direction to the main coils, complete the demagnetization of the clutches.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXI-XXIII. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

The effort to bring to justice the members of the contracting firm who conspired with ex-Captain Oberlin M. Carter to defraud the Government in connection with work in the Savannah District again seems likely to meet with success. The story of the indictment of these contractors and how they escaped removal from New York to Georgia for trial through the ruling of a Federal Judge that the whole question of their probable guilt must be investigated before the order for their removal could be made, was told in our issue of April 12.

For a month past new proceedings have been in progress before a United States Commissioner in New York and the Government authorities have presented evidence of the guilt of the indicted parties exactly as if they were now on trial. The farce of putting the Government to the expense and delay of trying the case twice over is evident enough; and it promises such a fine refuge to those who defraud the Government that it is no wonder that proposals to amend the law meet with strenuous opposition.

A feature of the testimony presented by the Government at this time was the appearance on the witness stand of Mr. R. F. Westcott, Carter's wealthy father-in-law. As will be remembered, Carter told all his friends and swore upon the witness stand at his trial that the money which he spent so liberally was given him by his father-in-law. The transparent falsity of this statement has been abundantly shown; but Mr. Westcott's own statement concerning it is of interest. He testified in the proceedings on Aug. 10 that Carter, when the charges were brought against him and the Board of Inquiry was appointed, sent for Mr. Westcott and asked him to go before the Board of Inquiry and testify that the large sums of money which he, Carter, had spent were gifts from his father-in-law. "I told him," said Mr. Westcott, "that I could not do that—that I could not swear to a lie." He consented, however, to take charge of some bonds which Carter did not wish to have found in his possession and received a package containing $450,000 in bonds from B. D. Greene, one of the indicted contractors. Later, when he learned more concerning the way in which Carter had acquired possession of the bonds, he refused to keep them longer, returned them to Carter and received a receipt for them, which was put in evidence. Efforts were made to induce Mr. Westcott to pose as a member of the Atlantic Contracting Co. in order to save Carter, but he refused to consent to this, and finally to get rid of the importunities of Carter and his associates he went to Europe and stayed until the trial was over.

In the light of such evidence—to say nothing of the overwhelming mass of other testimony which the Government has presented—no one of intelligence can have the least doubt of the guilt of Carter and his co-conspirators; and their hypocritical assumptions of innocence deprive them of all claim to sympathy. The wonder is that they succeeded in hoodwinking so many intelligent men into a belief in their honesty and an energetic advocacy of their cause. Is not the public entitled to some apology from Mr. Wayne MacVeagh, for example, who was so outspoken in his declaration that his complete certainty of Carter's innocence preceded his consent to plead his cause before the Attorney-General and incidentally in the public prints; or from Ex-Senator Edmunds, who tried to convince the public that Carter was guilty of the trivial offences charged, but innocent of the main ones. It is in the engineering profession, however, that the most determined attempt was made to save Carter's reputation. Witness for example his own letter in our issue of Sept. 28 last. But it is precisely here that his guilt deserves to be most plainly set forth; for his crime was a crime not only against his country but against his profession. It gave the most serious blow to public confidence in the honor and honesty of engineers that has been given in many years. This is the reason why we take space to present the above final and most convincing proof of his crime.

PASSENGER TRAFFIC AND PASSENGER PROFITS ON AMERICAN RAILWAYS.

How to make a profit from passenger traffic is a problem which continually besets most American railway managers, and in a good many cases the problem is given up as unsolvable. Every railway, in order to furnish reasonable accommodation to the public, must run a great many of its passenger trains with too few passengers to pay the actual train expenses. It must make enough profit on its better patronized trains to make up for this loss and leave a margin of profit besides, else its passenger traffic cannot be said to be on a satisfactory basis.

Taking the United States as a whole, only a little over one-fifth of the total earnings of railways are derived from the passenger traffic. No railway company, so far as we know, so keeps its accounts as to determine what proportion of its total expenses is properly chargeable to the passenger department. Any such division would be really an arbitrary estimate in any event. If it were made, however, it would probably show that a large proportion of American railway lines are conducting their passenger traffic at a loss, while others are merely paying expenses and deriving no profit proportionate to the investment and the volume of business done.

This is certainly not a satisfactory showing, and it ought not to be accepted as a permanent state of affairs. It may be of interest, therefore, to discuss some of the conditions which confront the passenger traffic manager and the means which may be taken to better the situation.

The natural remedy which at once suggests itself for a business carried on at a loss is to increase the selling price of the goods, or in other words, raise the rates of fare. But in the case of the railways this is well-nigh impossible. Apart from competitive influences, an increase in the rates of fare will certainly be followed by a decrease in the volume of traffic. Moreover, in many parts of the country any such change would be apt to result in hostile legislation. In fact the pressure toward a reduction in railway passenger rates has continually to be met by the railways. Two courses, therefore, are open to the railway manager seeking to increase passenger profits. He can seek to increase the volume of traffic or to reduce expenses. In both these directions there is room for successful work.

Perhaps the most difficult class of traffic to deal with profitably is the local passenger traffic. On at least three-quarters of the mileage of American railways the local traffic is very thin during most of the year. Yet a train service must be maintained for the public accommodation, and trains must be run at all seasons and in all weathers, while wages of trainmen, stationmen and other employees and other running expenses go steadily on, and are scarcely less in the months of lightest traffic than in those of heaviest travel.

It is the generally accepted principle that because of this accommodation to the public a higher rate should be charged for local travel than for long-distance journeys, where the variation in volume of traffic is not so great and the train service can be altered to suit it to some extent. The economic soundness of this principle can hardly be questioned; yet recent years have shown that to follow it has been in some cases an unwise business course. The adoption of the zone system on European railways and the remarkable development of electric railway traffic in this country are examples of the great stimulation to passenger traffic which results from the establishment of low fares and fixed fares for short distance journeys. There are cases where electric railways are now doing a large and profitable business, carrying passengers between cities where a steam railway connection had existed for years and had earned barely enough to pay the expenses of a few infrequent trains. Of course it is true that other causes have helped to build up the electric railway traffic. People ride on the electric cars because they run at frequent intervals and because they take and leave passengers near their own doors without a journey to a railway station. When all allowance is made for this, however, it must be conceded that a good part of the growth in electric railway travel is due to their low fares.

Judging by electric railway experience, it would probably pay steam railway companies to lower their local rates in districts where the population is sufficiently dense, as the increase in travel would more than offset the reduced earnings per passenger. Here again, however, another difficulty presents itself. It is well-nigh impossible to lower the local passenger rate per mile at a few points on a system without bringing about a general all-around reduction. Railway managers and doctors of political economy may agree that the passenger rate ought to vary with the volume of traffic; but the general public takes a different view of the matter. "Charge us more than the rich city people for riding on the cars, will they?" says the farmer-legislator; and he brings in a bill reducing all passenger fares to the scale fixed on suburban commutation tickets.

Desirable as it might be, therefore, from a business point of view, to stimulate traffic by lowering rates in the vicinity of cities and large towns while maintaining rates in the thinly-populated districts, it is a scheme which can seldom be successfully adopted.

A curious plan has been followed for some years past by several railways in northern New England with respect to the use of mileage tickets. It consists in making mileage tickets good to the bearer and doing away with the time limit upon them. The result is, of course, that nearly all the local passengers and many through ones travel on mileage tickets. Those who do not purchase mileage books of their own either borrow from some friend or rent books from dealers who make this a special line of business and are to be found in every town. The commission charged by these dealers is ¼ ct. per mile, and the average passenger profit of the railways, taking the country as a whole, is probably little more than this. In other words, these concerns which rent mileage tickets to travelers are receiving about as much

per passenger mile traveled as the profit made by the railways themselves.

It need hardly be said that the removal of all restrictions upon the use of the mileage ticket takes away its excuse for existence. The mileage ticket is sold at a low rate on the theory that the purchaser is a wholesale user of transportation who will be induced to travel more extensively by the grant of the lower rate. To allow any and every person to travel on a mileage ticket is practically equivalent to reducing all rates to the mileage level. In fact, it is on the whole worse for the railway company, for there is not the stimulus to travel which would result if the rate were placed at once on the mileage basis and the traveler had not the bother of obtaining mileage tickets from a broker and returning them at the end of his journey with the added expense of the broker's commission.

Here, again, it is a peculiar condition which the railway traffic manager has to meet. The users of mileage tickets, under the old plan where the ticket was limited, were continually loaning them. The pressure upon conductors to permit others than those named in the ticket to travel upon it was very strong. Identification was generally impossible. It was doubtless difficulties of this sort that brought about finally the abolition of the restrictions as to the use of mileage tickets upon the roads named; but as we have already seen, it would have been better for the railways to have abandoned the mileage tickets entirely and adopted the mileage rate as the basis for all passenger fares.

It may be of interest to note in this connection that the average rate per passenger mile is already below the 2 ct. point, taking the United States as a whole. In the Middle States, during the last fiscal year for which statistics are at hand, the average rate per passenger mile was only 1.786 cts., the average rate being brought down, of course, by the great number of season ticket holders who travel at much lower rates. There can be little doubt that on a large proportion of the railways a uniform rate of 2 cts. per mile is likely to be taken as the standard in fixing both local and through rates in the near future and that the prevalence of such a fixed and uniform rate will do much to stimulate passenger travel.

The matter of excursion rates is one which claims more and more attention from the passenger department, and the volume of excursion travel reaches proportions which were undreamed of a few years ago. The great point to be borne in mind in the conduct of excursion traffic is to so arrange it that it will interfere with the income from regular traffic as little as possible. If this is done, and if sufficient volume of traffic can be secured, large profits can be made from excursions. The average earnings of a passenger train in the whole United States is only 97½ cts. per mile run, which means, of course, that a great proportion of the trains are run with much smaller earnings per mile. An excursion train, on the other hand, may carry 500 to 1,000 passengers and even at rates of ½ ct. to 1 ct. per mile for each passenger, this means a great profit.

It is sometimes argued against excursion traffic that people will spend only about so much on railway travel in any event, and that excursion travel, therefore, causes a falling off in the volume of regular travel. While there may be some such effect noticeable in isolated cases, it appears true that in the long run excursion traffic really stimulates travel. People are induced by excursion rates to form the habit of traveling. The visit of one family to a place brings their friends to the same place. The habit of city people visiting the country and country people the cities grows more common every year, and a very large proportion of this travel has been stimulated in its growth by excursions.

A feature which deserves more attention from railway managers than it has received is the provision of accommodation for different classes of passengers. We do not mean by this that the European class system is likely to be adopted here or that it would be anything but a source of objection and expense if it were tried. There are, however, two classes of travelers which are not now as well provided for as they should be, and whose needs it would pay the railways to cater to. The first class is the men and women who want a little cleaner and more comfortable accommodation than the ordinary day coach and are willing to pay an extra price to secure it. It may be said that the Pullman service meets this demand sufficiently; but we do not believe this is the case. The Pullman parlor car service is too expensive, and caters too little to the wants of the traveler going a moderate distance to fill the demands we have in mind. There are many reasons why a railway should find it unprofitable to conduct its own sleeping car service and yet very profitable to provide a parlor car service on trains where such accommodation is likely to be in demand. Such cars as we have in mind need be little more expensive in first cost than an ordinary day coach and a special conductor is not at all necessary. What is wanted is particular care in keeping the cars clean, better provision for heating, lighting and ventilation and more room than can be assured the passenger in the ordinary day coach. These need cost a railway company so little that the extra charge for such service could be placed at a point low enough to make it popular with travelers while still leaving the railway company a good profit.

The second class for which better provision might be made by the railway companies is the class which cannot afford the money to pay the ordinary rates of fare. An enormous amount of traveling is done on freight trains every year for which the railways receive no revenue whatever. Not all of it is done by tramps by any means. In the changes in the labor market which are all the time going on, workmen have to go from place to place in search of employment, and how can they save money more easily than by stealing a ride on a freight train? It is exceedingly difficult to stop this practice, no matter how good the discipline of a railway's staff of employees. Trainmen will join heartily in the work of keeping tramps and toughs off from trains, but the respectable fellow-workingman who is down on his luck and looking for a job is another matter.

It is not worth considering what can be done to stop this class of "dead-heading" by providing accommodation for men of this class at a price within their means and of a sort that would prevent it being taken advantage of by passengers able to pay the regular fare? We do not mean by this to suggest the general introduction of "immigrant" or "Jim Crow" cars on regular passenger trains. Such accommodation as we have in mind might be afforded by attaching once or twice a week a special car to a local passenger or freight train running between important cities. An old passenger coach with plain wooden benches and such fittings that the whole interior could be washed out with a hose and kept in sanitary condition would meet all requirements.

Still more in this direction might be done by running special excursion trains to points where there is a temporary demand for labor. In fact, something of this sort is already done, we believe, by some of the Western railways in the shape of harvest excursions. Only a beginning has been made, however; and the field is one which can be cultivated much further. Many will remember the exodus from the mining towns of Colorado which took place in the summer of 1893 when the eastbound freight trains were covered with men going to Eastern harvest fields in search of employment. These men were not all penniless by any means; but they were undoubtedly unable to pay the regular fare, and the necessity for their removal to the East was urgent. Had the railways met the emergency with special trains at very low rates of fare, it is probable that thousands would have patronized them rather than undertake what was doubtless to many their first experience in stealing a ride.

Much more might be said as to ways and means for increasing the volume of passenger traffic; but space permits only a final word regarding the means for increasing profits by reducing the cost of operation. The greatest opportunity for economy in the passenger department and indeed in the whole railway service is in the conduct of local passenger traffic. Here is the point where the cost too often exceeds the receipts. The average number of passengers in a passenger train, taking the United States as a whole, is only 39. This means that thousands of trains are running in local passenger service with only half a dozen to a score of passengers. Yet to carry this small paying load there is provided a locomotive, and one to three cars with a train crew of never less than three men and often five or six.

The great need to-day in railway service is for an independent motor car which can be operated by two men and which will perform local passenger service on lines of thin traffic at less cost than the ordinary steam locomotive with its train. The electric car cannot meet the demand, for the cost of equipping the track with conductors and maintaining the necessary supply of power is too great, and it is necessary that the use of the track by ordinary passenger and freight trains shall not be interfered with. Experience on street railways has given no ground for hope that the storage battery car can furnish the solution of the problem. Inventors and engineers are hard at work developing compressed air, hot water and various forms of gas, oil, and gasoline motors to meet the conditions set forth; yet at present we know of no system whose practical success has been fully proved.

A short time ago it appeared that a solution had been reached in the steam motor cars which were tried on various roads; but these have unfortunately been found more or less defective in service. Nevertheless it is in this direction, we believe, that success will finally be reached. More intelligent designing can overcome faults of mechanical detail; and steam has a flexibility and an adaptation to all conditions of service which are absent from every motor employing any form of stored power. If it is feasible to use steam to drive pleasure carriages on ordinary roads, it is certainly feasible to adapt it to propel a car running on rails. We have strong faith that a successful steam car will yet be developed. Such a car would open the way for a great reduction in the cost of handling local passenger traffic on American railways and the conversion of what is now too commonly a source of loss into a source of profit.

LETTERS TO THE EDITOR.

Device for Holding a Plumb Bob Line.

Sir: With reference to Mr. Rogers' letter, in your issue of July 5, I enclose a sketch of a simple device for lengthening or shortening the plumb bob line which I have used for some thirty years. The slide is of bone or hard wood about 2½ ins. long, ¼-in. wide and 1-16-in. thick.

Yours truly, Edward Mohm.

Victoria, B. C., July 14, 1900.

Interpolation of Contour Points.

Sir: In your issue of July 26, Mr. C. D. Ward gives a method for the interpolation of contour points, by the use of a stretched piece of India rubber. I recollect that Mr. R. Meade Bache, of the U. S. Coast and Geodetic Survey, devised and, I believe, patented a similar device about 30 years ago. Mr. Bache's apparatus admitted of stretching a piece of elastic tape to any desired tension and holding it under such tension. The tape was furnished with a scale of equal parts and was used for the purpose of interpolating contour points or of plotting the location of soundings. It was found that elastic tape that would stretch with a sufficient degree of uniformity for plotting such locations with accuracy could not be obtained, and the apparatus was therefore not available for the purpose for which it was originally devised, but it was for a time used by certain cutters for cutting men's clothing and I believe it proved quite satisfactory for this purpose. The method of interpolation by equidistant parallel lines drawn on tracing paper, as already described in a former issue of your paper, has long been in use and leaves little to be desired in the way of accuracy and simplicity, while it is of quite rapid application.

Very truly yours,

Horace Andrews, M. Am. Soc. C. E.

Albany, N. Y., Aug. 8, 1900.

Centrifugal Pumps Under High Heads.

Sir: In reading over your valuable article on "Tests of Centrifugal Pumps Under High Heads," in your issue of August 9, the writer could not reconcile the constant or peripheral speed shown in Fig. 1 in the case of the reverse curve or Rankine shape, which should be marked (e), with his own experience in extensive experiments with centrifugal pumps in the Steven's Institute laboratory. Further along in the article, however, in the middle of the first column on page 99, he discovers that the constant for blade (e) should be 394 instead of 994 as printed on the diagram. As the error entirely reverses the proper status of the shape of the blade as affecting the speed of the runner, it should be corrected. In all the experiments made by the writer, the Rankine or reverse curve shape was shown to cause the slowest speed of runner to maintain a given pressure and the mechanical efficiency of the runner was never up to the efficiency of the Appold or backward curve blades except in the case of very low heads. As the practice in Rankine's time confined the use of centrifugal pumps to rather low heads, opportunity was perhaps never given him to discover his error in the choice of blades.

Yours truly, H. S. Wood, C. E.

Park Row Bldg., New York City, Aug. 9, 1900.

(In addition to the above corrections it should be noted that, by an oversight, the author's name was omitted in the title of the article referred to. The paper was prepared by Mr. Lewis A. Hicks. —Ed.)

Notes and Queries.

M. E., New York city, desires the address of any firm which makes a business of coating iron sheets or bars with lead.

THE CONSTRUCTION OF "LONG CECIL", A 4.1-IN RIFLED BREECH-LOADING GUN, IN KIMBERLEY DURING THE SIEGE OF 1899-1900.*

By Edward Goffe, Assoc. M. Inst. Mech. E.†

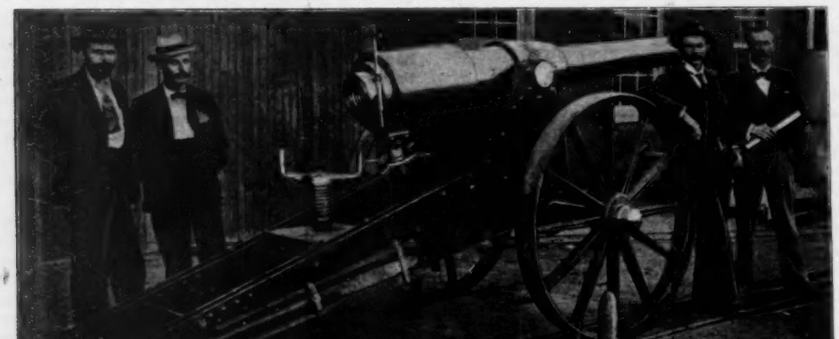
The object in view was to make a gun of greater power than those possessed by the garrison, which were 2.5-in. R. M. L. guns (7 pdrs.), and were not big enough to effectually reply to the enemy's 15 pdrs., or to make any impression on his works. A gun of about 4 ins. bore, firing a shell of 25 lbs. to 30 lbs. weight, appeared to meet the case, and to be possible of construction.

The possession of a billet of hammered mild steel (originally intended for shafting and ordered as such), 10½ ins. diameter and 10 ft. long, made by Messrs. Sybry, Searls & Co., of the Cannon Steel Works, Sheffield, and of several bars of 6 × 2½-in. Low Moor iron, in the workshops of the De Beers Consolidated Mines, really suggested to the late Mr. Geo. Labram, Chief Engineer to the company, the possibility of making the gun by boring the steel bar to form the tube, to be strengthened by rings shrunk on, made of the Low Moor iron. This resulting gun would evidently be of a type similar to an early "Armstrong," heavy for the work done compared with one of a more modern type, but in this case weight was a minor point to be considered, ease and quickness of manufacture being perhaps the leading ideas.

*A paper read before the Institution of Mechanical Engineers of Great Britain at the London meeting, June 28, 1900.

†Chief Draftsman, De Beers Consolidated Mines, Kimberley, So. Africa.

The first difficulty met with was the resistance of the military authorities to the attempt to make the gun, but as this was hardly a mechanical difficulty, further reference to it may be out of place. However, on Christmas Day, 1899, Mr. Rhodes, Chairman of the company, gave the order to Mr. Labram to make the attempt. Work was immediately started, and then the difficulty consequent on ignorance, on the part of both Mr. Labram and the author, of practical gun design, was first met with. This was overcome by a search in all books available. The sources of information were: The articles on Gunnery, etc., in the Encyclopædia Britannica; the military treatise on "Ammunition" (which had been previously used in gaining information to make shells and cartridges for the 2.5-in. guns earlier in the siege); articles on modern guns in "Engineering," etc.; and from the military "Text Book on Gunnery," brought forward by an enthusiastic volunteer officer, and which proved very serviceable. During



(a) (b)

FIG. 1.—4.1-IN. BREECH-LOADING SIEGE GUN "LONG CECIL," MADE AT THE WORKSHOPS OF THE DE BEERS CONSOLIDATED MINES DURING THE SIEGE OF KIMBERLEY, 1899-1900.
(a) The late G. Labram, Chief Engineer De Beers Consolidated Mines, Formerly a Resident of Milwaukee, Wis. (b) E. Goffe, Chief Draftsman De Beers Consolidated Mines.

the progress of the work in the shops, assistance was also given in many details of gun-shop practice, the form of special tools used, etc., by several of the employees there, whose previous experience in Woolwich Arsenal, the Elswick works, and elsewhere, was willingly given to forward the work in hand.

Design and Calculations.

Approximate calculations only were made, for two reasons, one that it was not considered necessary to go into very fine calculations when the two principal factors, the powder pressure and the test strengths of the materials to be used, were not known, and could only be estimated, recourse being preferably made to comparisons of the performances of similar guns. The other reason was that time was pressing—the designing, and supplying of sketches going on simultaneously with the making of the gun in the workshops.

The stock of powder in the town was of many kinds, ranging from "mealed" to compressed cylinders 1⅝-in. diameter by 2 ins. long. Most of it had been kept for a long time, much of it over ten years for certain, but it did not appear to have deteriorated, still retaining a good glossy surface. The cylinder powder (black) was evidently the most suitable for use, but there was not very much of it, so preparations were made to compress the finer powder into blocks, and so form a slower burning powder. The possibility of the compressing not being successful when the stock of cylinders was exhausted, and of having to use all kinds, had to be faced, but there proved to be sufficient cylinders to provide cartridges as long as the gun was fired.

From data available, it appeared that 50,000 lbs. per sq. in. would be a suitable maximum pressure to allow for, that being about the maximum pressure calculated, when using a charge of 5 lbs. of powder in the space which would be available for a powder chamber. But while using the slow-burning powder the shell presumably would begin to travel before that pressure was attained. Many charges of 6 lbs. were used while the gun was in action, the maximum pressure due to these conditions appearing to be about 90,000 lbs. per sq. in., but for the same reason, probably the actual pressure reached would not much exceed that obtained from the use of the smaller charge.

A powder chamber of 4.25 ins. bore it was found would just contain seven cylinders of powder, four of [illegible]-in. diameter, and three of 1⅛-in. diameter, their combined weight for 2 ins. of length being just 1 lb. With this diameter of chamber, to obtain a normal air-space the length required to be about 12 ins. Next the breech screw must necessarily be about 5½ ins. diameter, and allowing a length of thread equal to 1¾ diameters and about 2 ins. for obturator, the length of the breech block would be, say, 10½ ins. The total length of the steel billet was 10 ft. ¾-in., so deducting from this 1 ft. 10½ ins. the length available for the bore was 8 ft. 2¼ ins., very nearly 24 calibers.

Upon this basis the strength was next figured out, and the tube alone first taken. Using a formula for the strength of a thick tube subjected to 50,000 lbs. per sq. in. internal pressure, the greatest stress in the material was found to be 70,000 lbs. per sq. in. This showed, as expected, that the tube could not be used without shrunk rings. By shrinking on two rows of rings, each 2 ins. thick, a reduction of the greatest stress in the tube to about 40,000 lbs. per sq. in., and that in the rings to 20,000 lbs. per sq. in., was calculated, and this it was considered safe to allow. That there was sufficient strength was evident; but the author would like to know really what pressure was attained at any time, the only sign of strain being that the powder chamber has enlarged slightly and is now barrel shaped, the diameter at the center being fully 1-32-in. greater than as originally made. This is apparently due to direct compression of the metal, as the outside diameter was carefully gaged when an opportunity was given by some of the rings being removed, and was found to be exactly as made.

Shop Work.

The order to make the gun was given on the evening of Christmas Day, 1899, and at the start of work next morning the billet of steel was taken into the machine shop. A lathe of 12-in. center with bed 14 ft. long was used, the extra length of bed required for working the boring bars and rifling gear being obtained by the use of the bed of a similar lathe set in line with it, with the headstock removed. This was already in position, being used when working on lengths of shafting, etc.

Most of the men required on the work had to be temporarily withdrawn from the redoubts where they were stationed, forming part of the Town Guard. During the building of the gun and making of ammunition, the workshops were always under fire from the enemy, many shells, including 94 pdrs., bursting around and passing over the buildings, none however actually doing damage; but it was very trying for a man to stay at work at a lathe or other machine, hearing shells bursting around, and not knowing whether the next would come inside or not, and all those who had that experience deserve appreciative mention for the way in which they stuck to their posts.

Figs. 1 and 2 show the general construction of the gun. The steel billet was first turned all over outside, a shoulder of ⅛-in. being made to take the thrust of the trunnion ring, the largest diameter being 10.5 ins. It was turned tapering towards the muzzle, a parallel part about 9 ins. long being left there to be used as a journal when boring. For boring, the breech end was held in a dog chuck with the muzzle revolving in a hard wood bearing, and first a twist drill 1½-in. diameter put right through. This was followed by a twist drill 3 ins. diameter; then the end was counterbored with a tool and a boring bit, Fig. 3, was

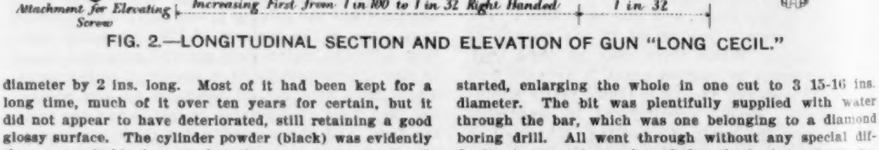

Rifling for 18 Calibres Length:
Increasing First from 1 in 100 to 1 in 32 Right Handed
Rifling Uniform Twist
1 in 32
Attachment for Elevating Screw

FIG. 2.—LONGITUDINAL SECTION AND ELEVATION OF GUN "LONG CECIL."

started, enlarging the whole in one cut to 3 15-16 ins. diameter. The bit was plentifully supplied with water through the bar, which was one belonging to a diamond boring drill. All went through without any special difficulty, but experience showed that the boring cut was too heavy, and it would have been better to have taken two cuts for that amount.

While this turning and rough boring was being done, which occupied about a week, the rings were being forged, nine being wanted for the first row, 10¼ ins. diameter inside (less shrinkage), and four wanted for the outside row, about 14¼ ins. diameter. These were all made from the 6 × 2½-in. Low Moor iron, a length of bar being cut, bent to a circle, and the ends welded together. As these were finished they were passed on to the machine shop, where they were turned, faced, and bored to gage. The trunnion ring was a greater undertaking than the plain rings, and the difficulty of making a satisfactory weld in so heavy a piece of work, with the appliances at his command, was overcome by the leading blacksmith, by work-

ing it out of a length of 6 × 6-in. Low Moor iron, starting a small hole through the center, and enlarging by successive heats until he had it to the required size for machining.

By the time the rings of the first row with the trunnion rings were made, the tube was ready to receive them. For shrinking, the tube was held vertically under a convenient derrick in the yard, first with breech end upwards. The ends of the bore were plugged, and a circulation of cold water arranged inside to keep the tube cool. The rings were heated on a plate over a wood fire, the bore being gauged until sufficient expansion was evident, then lifted by the derrick over the end of the tube and dropped into place, the trunnion ring being the first to go on, resting against the shoulder. As a precaution against possible tra endways while cooling, each ring was clamped by long dinal bolts, and the adjoining one on which it

Tool for Roughing. Tool for Finishing.

FIG. 3.—TOOLS USED IN BORING TUBE FOR GUN.

rested kept cooled down by a stream of water from a hose pipe. The tube was reversed to put on those rings in front of the trunnions, and, the whole of the first row being in place, it was returned to the lathe, and the outside of the rings turned up to form a seating for the second row over the powder chamber. The process of shrinking these was the same as for the first row, and when they were on, the barrel was again returned to the lathe for finishing. The final boring was then begun, the tool used being a studded bit with double-ended cutter, Fig. 3.

Meantime, the question of rifling had been gone into, and, the increasing twist appearing more desirable and easier on the gun than the uniform twist, it was decided to make it so. To effect this the rifling attachment, as shown in Fig. 4, was devised, the idea being given to the author by remembering one of Sir W. Anderson's lecture diagrams. The author has since learned that this method is still used in gun factories. The drawing shows a channel-iron bolted to two cross channels, which are bolted to the ends of the lathe bed. On this channel-iron the developed curve of the spiral—a semi-cubical parabola—was set out by its ordinates. A planed bar to act as a former was bent to the curve, and screwed down with countersunk screws. The hardwood blocks, forming the guides to the rack, and bearings for the rifling bar, were bolted solidly together and to the saddle of the lathe. The end of the rack (which was a stock one as used on the washing machines) is furnished with one little roller, traveling on the "former" bar, contact being kept by a cord attached to the underside of the rack, carried over a pulley at some distance and having a weight at the end. A small guide pulley should be shown on the saddle to allow for vibration of cord with travel of saddle. The traversing of the saddle was done by the leading screw of the lathe, a small belt pulley being put on in the place of the usual "change" wheel, with a belt from the overhead drive.

A detail of the rifling head is shown in Fig. 4. It was formed of a solid block of steel, turned to fit the bore of gun, into which the end of the rifling bar was tightly screwed. The tool was able to revolve slightly on its pin as a center, being kept up to position by the set screw and packing block, which also regulated the depth of the cut taken, while clearance on the return stroke was possible by the giving of the spring. A felt pad held by a washer was attached to the head in front of the tool, while the head drew another wad of felt behind it, to clean the bore of cuttings as made, and a supply of soapy water under pressure was forced in behind the head, the two semicircular grooves being provided to allow the supply to get to the cutting edge. The only serious trouble experienced in the workshops processes was at this point, when it was found most difficult to get the tool to cut properly, and a lot of time was spent in trying to find the reason, three grooves only being got through between about ten o'clock one morning and late the following night. The material could not be at fault, as it had been found perfectly good, without flaws, and very clean cutting up till then, and new tools and different lubricants were tried, but with no success, until the packing block, which took the pressure off the tool, and which consisted of a small piece of iron, was noticed to be denting, when a new one of cast steel hardened was put in the place, and no further trouble was experienced, the remaining 29 grooves being finished in about eight hours' work.

The rifling was started from the extreme end of the barrel at the breech, so that there was about 2 ft. of length to spare, to be afterwards bored out for breech and powder chamber. Thus, should a false start have been made with a groove by accident, no damage would have resulted. After rifling, the bore was lapped out to take off any roughness left by the tool, and then reversed in the lathe and the powder chamber bored out, a double-ended tool similar to the finishing tool, in Fig. 3, being used.

The breech-block screw having meanwhile been made, the inside was cut, and the block fitted in. In cutting this thread in the barrel, the question of the ending of the cut inside had to be met, and the simplest way seemed to be to let the tool finish in a clearance hole, and to drill this hole inside. The little drilling machine, Fig. 4a, was made, being worked by a gut band from a convenient source of power.

The breech block and obturator are shown in detail in Fig 5. The De Bangé system of obturation was adopted, that appearing to be the most efficient and easily made. The obturator pad was made of rings of sheet asbestos soaked in melted tallow, and proved quite successful. The breech block as made first and used with radial firing is shown at (a). The block was of hammered mild steel, the same material as the tube of the gun, screwed with a V-thread of ¾-in. pitch with flattened top and bottom. The handle-bars and plate are one forging, fastened to the screw with six tap bolts. The obturator bolt with mushroom head was made of mild steel, 1½-in. diameter, shouldered near the middle to 1¼-in. diameter, and held by lock nuts in a recess at the back. As thus made about 100 rounds were fired with this obturator. Fig. 5, (b) and (c) show it as subsequently made, the reasons for which alterations will be described later.

It was arranged originally to have an interrupted screw, cut away in three sections, so that one-sixth of a turn of the handle-bar would release the breech block; but consideration of the time to be saved by not cutting it, which it was thought would be at least two days, and the further consideration of strength, induced the author to urge keeping the screw intact, the actual extra time taken in unscrewing the whole way being only a few seconds.

With the interrupted screw, a safety vent-closing device was necessary, and one was made. One handle, as turned to unscrew the block, moved a plate sliding on the end of the barrel, which by means of a pin working in a diagonal slot closed the vent with a light plate, the reverse action taking place when the handle was turned to screw up the breech, so that the vent could only be open when the breech was tight. With the plain screw this was not so urgently required, and although the guard over the vent was retained for a time, it was not used. The vent hole was drilled in the gun barrel after the powder chamber was bored and the breech fitted, and was ¾-in diameter. About an inch at the top was tapped with ⅛-in. gas thread, and a copper plug fitted as tightly as possible for the whole length, being screwed at the end to fit the hole. This copper plug had a small hole drilled through it to fit the friction tubes used.

A relieving hole ⅛-in. diameter was also drilled through the underside of the barrel from just behind the obturator,

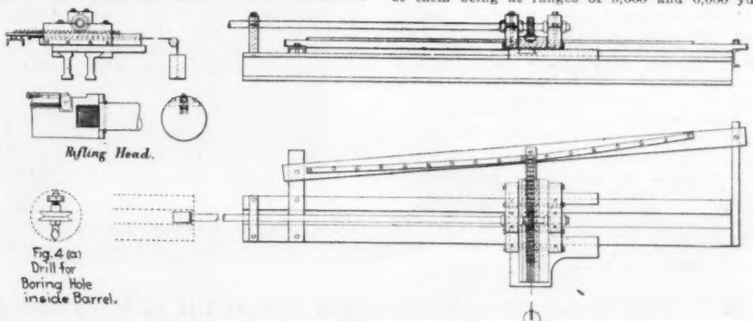


FIG. 4.—RIFLING DEVICE FOR "LONG CECIL" GUN.

to prevent any damage to the thread from the product of explosion, should the obturator ever act imperfectly. But at no time during firing was any smoke noticed coming from it. A flat place true with the axis of the gun was planed on the top for standing the clinometer upon. A gun-metal casting bolted to the underside was cup-shaped to fit the end of the elevating screw, which was turned to a ball. This it was found necessary to replace by a hinge joint, as the gun jumped on firing, and the elevating screw when in an inclined position tended to fall over, and the cup did not come fairly onto the ball end. The back sight, copied from that of one of the 2.5-in. Royal Artilley guns, was provided with a fine traverse for wind allowance, etc., and was set at an angle of 2° from the vertical (to the right) to allow for "drift" of shell, which was found on firing to be almost exactly correct. The front sight on the trunnion was first made as a bead in a small tube, but was afterwards altered to a knife edge without the tube. This completed the gun itself, ready for mounting on its carriage, as first turned out of the workshops.

Carriage.

The carriage having been made in the meantime was ready for the gun. Its general construction is well shown in the accompanying photograph, Fig. 1. It was formed of four steel plates ¼-in. thick, cut to shape, riveted together in pairs, 2½ ins. apart, with distance sleeves on the rivets, and with gun-metal castings also acting as distance pieces and riveted in, for trunnion and axle bearings. The two pairs of plates were bolted together with shouldered bolts, 17⅛ ins. apart, and with a rubbing plate at the trail end, which was also provided with an eye-bolt for hanging to limber. The elevating screw was of steel, 2¼ ins. diameter, with square thread ¼-in. pitch, working in a nut pivoted between the side frames, and provided with a hand-wheel. The axle was 4½ ins. diameter keyed into the side frames.

The wheels were the only part not actually made, and they were a pair belonging to a portable engine and suited the purpose admirably. They were bored out, had gun-metal bushes driven in, bored to fit the axles, and brass dust caps screwed on outside. The height of the center of the trunnions from the ground is 5 ft. The center of trunnions is 5 ins. forward of, and the point of contact of the trail with the ground 9 ft. 6 ins. behind, the vertical line through the axle, and the wheels are 5 ft. c. to c.

Testing the Gun's Range.

With 24 days of continuous work the gun was ready, and on Jan. 19, 1900, it was taken out for testing and ranging, a firing platform and redoubt having been built at No. 2 Washing Machine, Kimberley Mine Floors, whence the Boer headquarters (the Intermediate Pumping Station of the Kimberley Water-Works Co.) and several of their gun positions could be commanded. The ranging was done with the assistance of the company's surveyors, one having a theodolite at the point of firing, while another, also with a theodolite, was stationed at a point about a mile distant, nearly at right angles to the line of fire. On firing each took observations to the spot the shell struck, and the angle of firing as shown by clinometer, time of flight, charge of powder, etc., also being observed and tabulated, the muzzle velocity was calculated, and range tables made for subsequent use, by Mr. C. D. Lucas. The back sight was not graduated for range, being only used for laying the gun, the firing party prefering to use the clinometer. The enemy appeared much disturbed when the first shells burst in their headquarters, and could be seen hurrying out in all directions, not expecting that they could be reached there, and there was no reply from any gun of theirs during the ranging trial. Mr. Rhodes was present the whole time and personally fired most of the shots, being very pleased with the performance of the gun, and the artillerists working it also were well satisfied with its shooting qualities. The trials having been completed, the gun was returned to the workshops for one or two minor alterations, including a new front sight and altered attachment for elevating screw, as already mentioned. These being completed, it was handed over to the firing party and was in action on Jan. 23.

While in action 255 shells were fired in all by it, most of them being at ranges of 5,000 and 6,000 yds., these being reached with elevations of 12° and 15° respectively, with a powder charge of 5 lbs., the shells being 29 lbs. in weight. With the same charge a range of 8,010 yds. was reached with an elevation of 24° 15′.

Ammunition.

It will be convenient here, before mentioning some further and serious difficulties experienced while the gun was in action, to describe the ammunition. The powder used has already been described. A good wool serge was chosen for the bags to form the cartridges, and they were made by a local draper, being hooped with silk ribbon. The "Ring" shell is shown in Fig. 6. The "Common" shell was similar, the only difference being in the absence of the rings cast in. Both kinds were used, their weight when filled with the bursting charge of 1 lb. powder being exactly 29 lbs. In making the shell the rings were first cast separately, then were mounted on a clay core, alternating tooth and space as will be noticed, the shell bursting better when thus arranged. This clay core with rings was then used as an ordinary core in the mold, and the metal poured. At first it was tried to cast them with the base solid, the core at that end supported by a "star," but this was not successful, the base being spongy in nearly every casting. Other methods were tried, and that adopted was to core them right through the base, that being downwards, and to pour in at a point about one-

third the height from the end. Sound castings resulted. The cored hole in the base was plugged with a brass plug screwed in tight, and before issuing for service every shell was tested by steam at a pressure of 125 lbs. per sq. in. to detect blowholes, but none failed at that test, and no "prematures" were complained of. The shells after casting were turned to gage, the point screwed for the fuse, and grooved for the copper gas-check, that being made from a ring turned and cut off to width required, then cut through with a saw, sprung into place and expanded into the dovetailed groove, afterwards being turned, and the relieving grooves cut. The insides of all shells were lacquered.

The percussion fuse was devised by Mr. Labram, his idea being to have the simplest possible one to make. The action of it is, that when the shell strikes and its forward motion checked suddenly, the plunger, which is filled with mealed powder, continues its motion forward, its impetus being sufficient to overcome the resistance of the safety spring and wires. The nipple strikes and explodes the cap, which is an ordinary percussion cap as used in sporting shot guns, the mealed powder is ignited and fires the charge in the shell.

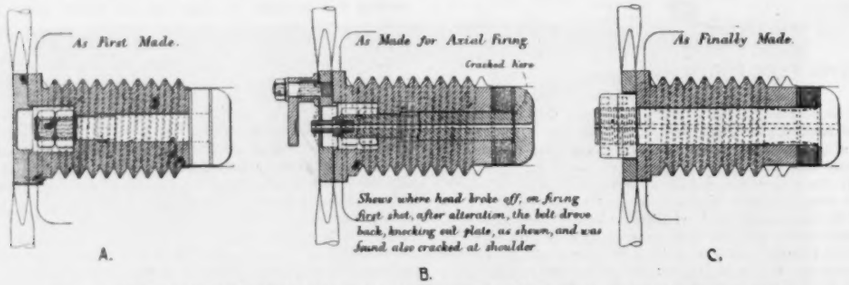

As First Made.
As Made for Axial Firing
Cracked here
As Finally Made
Shows where head broke off, on firing first shot, after alteration, the bolt drove back, knocking out plate, as shown, and was found also cracked at shoulder
A.
B.
C.

FIG. 5.—SECTIONS OF BREECH BLOCK AND OBTURATOR FOR "LONG CECIL" GUN.

It may be mentioned in passing that ammunition, both cartridges and shells—"common" and "ring"—had been made in the workshops and supplied to the garrison since early in November, for their 2.5-in. R. M. L. guns, the government supply having been exhausted in about a month.

Repairs and Alterations.

From the time of its being handed over to the firing party on Jan. 23, the gun was fired steadily, the only trouble being a tendency for the end of the breech block to "upset" and get too tight in the screw. This was easily remedied by first easing the thread and subsequently removing one and then two threads at the end. On Saturday night firing ceased as usual, Sunday being observed as a day of rest—from gun-firing—by the Boers. But at daybreak on Monday morning the first shot fired by "Long Cecil" was productive of an extra loud and peculiar report, and the idea that something had gone wrong was general. A telephonic message came from the redoubt immediately afterward and an examination showed that the second ring in the outer row had burst through the line of the vent hole. The gun was at once sent down to the workshops for repair. To take off the first ring the foundry cupola was lighted, the gun hung from the crane with the breech in the sand, and a ring of metal run round the first ring which in two or three minutes expanded and dropped off, releasing also the broken one, to replace which a forging was already in hand. On removing the gun from the sand a further examination showed that the two rings of the first row immediately under the outer broken one were also broken, these having broken straight across on alternate sides of the gun. To remove these necessitated a repetition of the process, one more outer ring—the third, and the first inner ring having to be expanded. New forgings were put in hand, and opportunity was taken then to make a careful examination of the tube, but no flaw or crack of any sort could be detected, nor any change of dimensions beyond the slight barreling of the powder chamber already mentioned, which does not seem to have increased with subsequent firing. The cause of the failure was not at all evident. Faulty welds were the first things looked for, but in vain; and although in the outer ring one part of the broken surface looked as if it might be an imperfect weld, in the two others there was no mark whatever, and no sign anywhere by which to trace the position of the weld. The outer ring had certainly broken through the vent hole, and from marks on the rings which appeared to be powder-smoke stains, the conclusion was come to that the radial venting was the cause; the copper vent tube not being tight enough to withstand the great pressure, had allowed the gases to travel around it, and get under and between the rings, bursting them by direct pressure, this action being assisted by a combination of favorable circumstances, namely, firing a 6-lb. charge of powder for the first shot in the morning, after the gun had been exposed to the cold air of the night, when the metal might be expected to be less tough than ordinarily. The outer ring being weakened by having the vent hole through it, with the possibility of the weld happening to be at the same spot, the radial venting was condemned, and the breech prepared for an axial vent, experiment being first made to see whether the "friction tubes" would strike through the distance necessary, which it was found they would do easily. The vent hole in the gun tube was tightly plugged, and the new rings when ready shrunk on. No alteration was made in the breech block beyond boring the vent hole through the obturator bolt, and providing a safety device to prevent the friction tube blowing out behind and possibly injuring some person. These alterations, as shown in Fig. 5, being completed, the gun was taken out to the redoubt again and put in action, but at the first shot under the new conditions, the obturator bolt (the same one as had been used all the time, and with which about 100 rounds had been fired) broke as shown in Fig. 5. A spare breech block had already been prepared with the obturator bolt increased in size to 2 ins. diameter without shouldering, and the end brought right through the back plate, but at the first shot this one also broke off short under the mushroom head. It was beginning to be an anxious time to know how to make something which would stand the shock, when one of the fitters said that he had "known a time at Woolwich when six or seven similar bolts had broken with successive shots"—which statement somewhat relieved the anxiety—and he further suggested annealing in oil as an expedient which might help. This was immediately done, several bolts being made for emergencies, but none broke after that. The present breech block is shown at (c), which also shows the peculiar drawing-down action taking place in these bolts. Three of them were used with two breech blocks from that time until Feb. 15, when Kimberley was relieved, about 50 rounds being fired by each bolt. The only way to account for the action seems to the writer to be that the shock of the explosion drives the whole bolt back compressing the asbestos pad. Then on the relief from the pressure, the pad expands again, tending to bring the bolt back to its original position, which is opposed by the inertia of the body of the bolt, causing a tensile stress in the bolt which is sufficient to cause permanent set at the point where the greatest stress comes, close to the head.

Kimberley was relieved before any further difficulties arose, and the gun is now resting, waiting for its next position which it is expected will be in a prominent position in the town, forming part of a monument to the memory of those who fell in the defence of Kimberley, and chiefly of him who originated it—George Labram—who, by his great mechanical skill and general resourcefulness in all matters, contributed in no small degree to that end, and who was most regrettably killed only a few days before relief came.

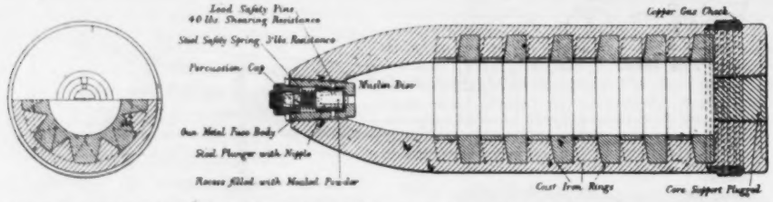


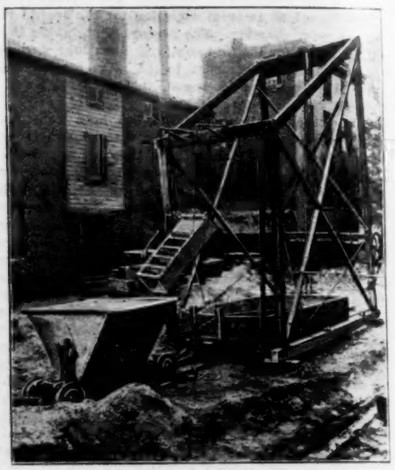
FIG. 6.—29-LB. "RING" SHELL FOR "LONG CECIL" GUN, MADE AT THE DE BEERS WORKSHOPS.

A NOVEL CONCRETE-MAKING PLANT

We illustrate herewith a concrete-making plant used at Baltimore, Md., making concrete for laying electrical subway ducts. The plant was devised by Mr. Chas. E. Phelps, Jr., Chief Engineer of the Baltimore Electrical Subway Commission.

As seen in the cut, a No. 6 Portable Gravity concrete mixer, made by the Contractors' Plant Mfg. Co., of Boston, Mass., is suspended to a light frame in position to deliver into a Hunt dump car. This concrete mixer was described and illustrated in our issue of Jan. 5, 1899; but many improvements have been made in it since that time, and it has come into extensive use, having been adopted on many large government works. In the chute of the mixer are set successive rows of inclined steel rods, staggered to insure a thorough mixing of the materials, and with deflecting plates at the sides. A gate at the lower end confines the material until a wheelbarrow load has accumulated. The gate is then opened and the barrow is filled.

As ordinarily operated, the stone, cement and sand are dumped in the proper proportions on a floor at the head of the mixer, the stone at the bottom, the sand next and the cement on top, each being roughly leveled off after dumping. The mass is then shoveled into the mixer, receiving a wetting from a perforated spray pipe, controlled by the foreman below, as it passes down the chute.



Concrete Mixing Plant; Baltimore Electrical Subways.

In the plant at Baltimore it was desired to dispense with the labor of shoveling the materials into the mixer. They are, therefore, dumped in the shallow box shown, in the proper proportions and leveled off as they would be on a mixing floor. This box is suspended from the overhead frame by pulley blocks, and the ropes from these are so connected to a windlass in the rear that as the rope is wound in, the rear end of the box is raised more rapidly than the front end, and by the time the box is in position to discharge into the hopper, it is on a steep enough incline for the materials to slide out by gravity.

THE RAILWAYS OF SPAIN AGGREGATED 8,068 miles of line on Jan. 1, 1899. Of this mileage 6,842 miles were of the standard gage (5 ft. 6 ins.), 1,221 miles were of various narrow gages from 24.6 to 39.37 ins., and there was one cog-wheel road of 5 miles. The principal railway corporations are: The Northern Ry. Co. of Spain, having 2,289 miles, equipped with 662 locomotives, 36 saloon cars, 366 first-class cars, 400 second-class cars, 897 third-class cars, 192 miscellaneous cars, 566 baggage cars, 9,515 box and crate cars for merchandise and cattle, and 2,734 open or platform cars, making a total of 14,726. The Madrid-Zaragoza-Alicante Rys. Co., having 2,277 miles, equipped with 392 locomotives, 31 saloon cars, 187 first-class cars, 179 second-class cars, 464 third-class cars, 102 miscellaneous cars, 340 baggage cars, 3,497 box and crate cars for merchandise and cattle, and 3,952 open or platform cars, making a total of 8,752 cars. The Andalusian Rys. Co., having 688 miles, equipped with 147 locomotives, 145 saloon cars, 78 first-class cars, 196 second-class cars, 256

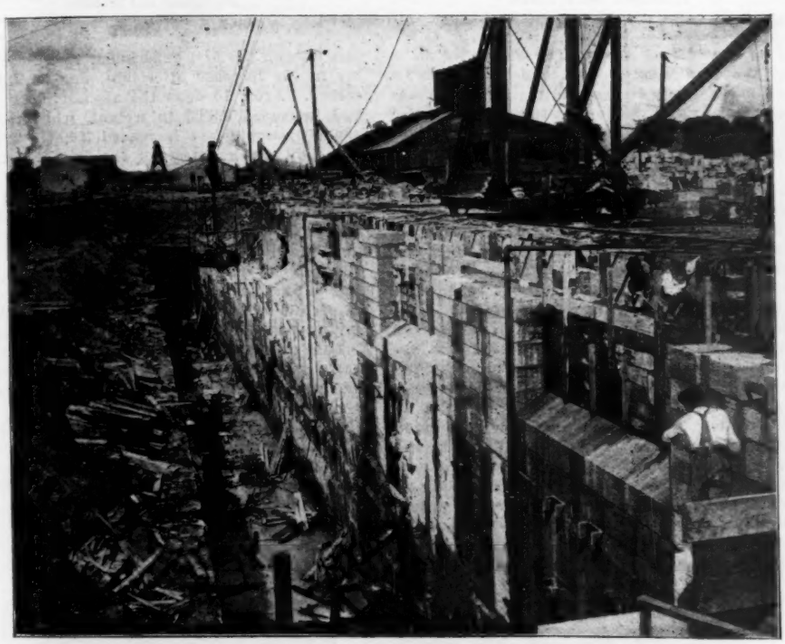
third-class cars, 32 miscellaneous cars, 126 baggage cars, 1,982 box and crate cars for merchandise and cattle, and 1,830 open or platform cars, making a total of 3,634 cars. The Tarragona, Barcelona & France Rys. Cos., operated by the Madrid-Zaragoza-Alicante Co. as the Catalan division, equipped with 154 locomotives, 15 saloon cars, 70 first-class cars, 132 second-class cars, 289 third-class cars, 71 miscellaneous cars, 75 baggage cars, 3,422 box and crate cars for merchandise and cattle, and 147 open or platform cars, making a total of 4,149 cars. The four systems above named had 1,355 locomotives out of a total of 1,835, and 31,296 cars out of a total of 40,197; the balance (480 locomotives and 8,901 cars) was divided among fifty smaller roads.

THE EYRE-CRAGIN NICARAGUA CANAL concessions is reported in press dispatches from Nicaragua to have been annulled by the Nicaraguan Government, in consequence of the company's failure to deposit the remaining $500,000 in gold required by the concession. The first announcement of the existence of the concession granted to the Eyre-Cragin syndicate, or the Interoceanic Canal Co., was made late in October, 1898, when a press dispatch from Managua, Nicaragua, stated that President Zelaya had granted to Messrs. Edward F. Cragin, Edward Eyre and Frank S. Washburn the right to build a trans-isthmian canal. The concession was to take effect on the expiration of the Maritime Canal Co.'s concession, which would be on Oct. 10, 1899. Among the terms of the concession were two requiring the company to pay

PROGRESS OF WORK ON THE NEW WHEEL-PIT OF THE NIAGARA FALLS POWER CO., NIAGARA FALLS, N. Y.

By O. E. Dunlap.*

Unless all signs fail, the National Contracting Co. will complete its contract on the new wheel-pit for the Niagara Falls Power Co. in the 20 months expected to be consumed when this work was started in November, 1899, which will bring an end to the operations about June, 1901. The present depth of the new wheel-pit is about 75 ft., and as it is to be carried to an approximate depth of 180 ft., about 100 ft. still remain to be excavated. The progress has been and continues to be quite satisfactory. Since the early mentions of this work a Lidgerwood patent cableway has been installed to aid in the removal of the excavated material from the pit. For the operation of the cableway two towers have been erected, one at each end of the pit. One has a height of 30 ft., while the other is 60 ft. high. The cable used is of steel rope 2½ ins. in diameter, and it is capable of lifting 10 tons. The length of cable between the towers is 600 ft., but the total length of cable used is 840 ft. The bucket used holds 2 cu. yds. of material. In the operation of the cableway the buckets are raised out of the pit and run to a point close by the high tower, where



VIEW SHOWING CONTRACTOR'S PLANT AND PRESENT CONDITION OF WORK ON THE NEW WHEEL PIT FOR THE NIAGARA FALLS POWER CO., NIAGARA FALLS, N. Y.
National Contracting Co., Niagara Falls, N. Y., Contractors.

the material is dumped from them into Goodwin gravity dumping cars, the operation being wholly in charge of the engineer located in a small building close by. In the construction of this cableway anchorages were provided at each end by sinking a round oak log 30 ins. in diameter and 25 ft. long, 12 ft. in the ground, and surrounding it with concrete and loading it with piles of rubble stone. These anchorages sustain a pull of 19 tons at each end. When the cars are filled they are run to the trestle of the Niagara Junction Ry., where the stone is used for making a roadbed in order that the track may be doubled at some future time. All blasting in the pit is done at off hours and dynamite is used. On the south side of the pit the masonry wall at the top is quite well advanced, as is shown by the accompanying cut. As this work is done the castings for various purposes are placed in the walls. These castings are of several kinds, and are for bearings, struts, girder bearings and penstock bearings. The stone used is white granite from the Queenston, Ont., quarries.

The shaft in front of the power house, extending down 180 ft. to the tunnel heading, has been sunk, and sub-contractor Mr. A. C. Douglass has progressed about 200 ft. in the removal of the upper bench of the tunnel extension. It will be remembered that this tunnel extension is to be of the same section as the original tunnel, which is 18 ft. 10 ins. wide and 21 ft. ¼-in. high, built in the form of a horseshoe. The length of the tunnel extension is to be 616.5 ft., making the total length of the tunnel 7,436.5 ft. The extension is being built on a curve, the length of which is 368½ ft., and which has a radius of 186½ ft. About the shaft, which is sunk in the bed of the inlet canal, strong walls of masonry are being built in order to protect the shaft from the water inflow when it is allowed to return to its normal state following the removal of a cofferdam 120 ft. long under the stone bridge leading from the power house to the transformer station.

In the inlet canal in front of the point where the new wheel-pit work is in progress there has been completed a cofferdam 550 ft. long. It is formed of two rock-filled cribs, the outer one 10 ft., and the inner one 8 ft. thick, with a clay puddle between them.

In the performance of their contract the National Contracting Co. will remove about 32,000 cu. yds. of earth from the pit and inlets and about 68,000 cu. yds. of rock will be taken out of the pit, and 13,000 cu. yds. of rock out of the shaft and tunnels. They have used about 800,000 ft. B. M. of hemlock in the construction of cofferdams, etc., and the castings, girders and pipes will take about 1,400,000 lbs. of iron and steel. The masonry calls for about 6,000 cu. yds. of cut stone, and 10,000 cu. yds. of Portland cement concrete will be used. In the linings, etc., 13,000 cu. yds. of brick will be laid, which means the consumption of 7,500,000 brick.

The plant necessary to carry on the work is quite extensive. It consists of ten 100-HP. boilers; four straight line Ingersoll air compressors, known as Class A; ten Sullivan Machine Co.'s rock channelling machines; six Ingersoll-Sergeant rock drills; three Ingersoll-Sergeant gadding machines; 10 derricks and hoisting engines; one Byer's traveling derrick; two 30-ton locomotives; 40 dump cars; three Goodwin gravity dumping cars; and about 1¼ miles of railway track. Night operations on the pit are conducted with the aid of a Wagenhall electric headlight, which has been installed about 30 ft. from the ground on the high cableway tower. This headlight throws its beam along the cableway or down into the pit as required. Arc lights are also placed in the pit.

Mr. Walter McCulloh, of Niagara Falls, is the local manager in charge of the work on behalf of the National Contracting Co., of which company Mr. George B. Burbank is consulting engineer. Mr. William A. Brackenridge, Resident Engineer of the Niagara Falls Power Co., looks after that company's interest in connection with the work.

*Niagara Falls, N. Y.

$100,000 upon the granting of the concession and $400,000 more four months from that date. It is owing to the failure of the company to meet the last obligation that the forfeiture of the concession is claimed by the present press dispatches to have been due.

A "BACK-ENDED" TEN-WHEEL LOCOMOTIVE is exhibited by the Southern Italian Rys. at the Paris Exhibition, the engine having the truck under the cab and being run with the cab in front. It was built at the company's shops, and some of the engines of this type are using oil fuel. The engine is a four-cylinder compound, with two inside and two outside cylinders, all connected to the same axle, and all having piston valves. The boiler has a long extension smokebox and a large firebox, the firebox extending over the rear axle of the leading truck. At the sides of the firebox are the coal bunkers, and the front end of the cab is wedge shaped, or what is popularly called a "wind-splitter." The truck has a long wheelbase, and its springs are not equalized. The valve gear is of the Walschaert type. The tender is a cylindrical tank car, with steel frame and three rigid axles, coupled to the smokebox end of the engine. The general dimensions are as follows:

Driving wheels (6)	6 ft. 4 ins.
Cylinders, h. p. (2)	15 x 25.6 "
Cylinders, l. p. (2)	22.4 x 25.6 "
Tubes, 273; length	13 ft. 2 "
Firebox	7 ft. 2 ins. x 4 ft. 11 "
Grate area	35 sq. ft.

THE ACTION OF WATER ON ASPHALT PAVEMENTS

By Daniel B. Luten.*

Sheet asphalt pavements frequently show signs of failure after five or six years of wear, by disintegration in spots, the cause of failure being usually attributed to water standing on the surface; brick or concrete gutters are usually required to prevent such action on that part of the pavement most subjected to water. With asphalt block pavements such safeguards are never required, the action of water apparently being too slow seriously to affect the life of the pavement. The action of water and traffic combined may have a different effect from that of water alone; traffic by compacting sheet asphalt may make it less porous and thus better able, perhaps, to resist the disintegrating effect of water.

An asphalt paving mixture is a very complex material, and the chemical action resulting from its exposure to air and to water is not well understood. Refined asphaltum is probably not seriously changed by exposure for a considerable time; but mixing the asphaltum with oil and with upwards of 80% of sand and other mineral matter, very considerably reduces its ability to resist the action of air and of water.

In Engineering News of March 22, 1900, there was published a report of experiments to deter-

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mine the action of water on asphalt, by Messrs. Whipple and Jackson. The tests were performed upon refined asphaltum, and showed that two years of immersion in water produced but very slight disintegration of the surface. The experiments further proved that certain varieties of refined asphaltum were affected to a greater extent than others. While these results are of great value as bearing upon certain uses of asphaltum, no conclusions should be drawn from them for purposes of comparison of paving mixtures. The writer believes that the reason for one variety of asphaltum showing a higher resistance than the others, was has been able to determine, ever been observed upon asphalt block pavements. It is not to be assumed, however, that water produces no ill effects upon the latter pavement. While water alone apparently has but slight action on asphalt block, it may serve to accelerate the wear of traffic. The view, Fig. 4, shows the asphalt block pavement on South St., Lafayette, Ind., laid in 1899, at a point where traffic has had its worst effect, producing a slight depression, as shown by the straight edge. There is no apparent disintegration, but the wear occurred at a time when the pavement was subjected to a continuous wet- terial remaining uninjured after the removal of the disintegrated portion.

The experiment showed the necessity for adopting some more satisfactory method of thoroughly removing the softened material. After some further trial, a wire brush was adopted, having bristles stiff enough to remove the softened surface, but which had no abrasive effect on either sample before immersion; the object being, not in any way to attempt to reproduce the wear of traffic, but only to remove the decayed asphalt at frequent intervals in order to accelerate the action of the water. It was found also that the two sam-

Fig. 1.—Canal St., Grand Rapids, Mich.
(Pavement laid in 1890.)

Fig. 3.—Massachusetts Ave., Indianapolis, Ind.
(Pavement laid in 1891.)

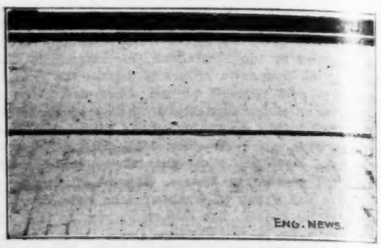


Fig. 4.—Slight Depression, South St., Lafayette, Ind.
(Pavement laid in 1899.)

FIGS. 1, 3 AND 4.—HOLES AND DEPRESSION IN SHEET AND BLOCK ASPHALT PAVEMENTS IN VARIOUS CITIES.

that the former probably contained a higher percentage of bitumen. In asphalt paving mixtures upwards of four parts of foreign matter are added to one part of refined asphaltum, and since the amount added is corrected for the impurities existing in the asphaltum, the purest can have no advantage over others, in producing a paving mixture that will resist water.

Fig. 1 is a photograph of a hole in the sheet asphalt pavement on Canal St., Grand Rapids, Mich. The pavement was laid in 1890, and has required frequent repairs for the last five years. The contractor, in a letter to the City Council, attributed the defects to the excessive sprinkling which the street received. The hole is about half way between crown and curb, and in the direct line of traffic; the straight edge is included in order that its shadow may assist in judging the depth of the depression, which is through to the concrete; the straight edge is 1 in. sq., in section. The cause of such disintegration might be an accidental depression retaining the surface water, which in time softened the material until the wheels cut it away. Such a spot increases in size very rapidly under the action of traffic, and necessitates prompt repairing.

Fig. 2 is a similar defect, located in the gutter ting for nearly four weeks. The contractor maintains that the wear is due to defective blocks, which might easily be true, as the inspection was by no means rigid. Since that time, the defective part has become hard and smooth like the rest of the pavement.

A series of experiments was conducted by the writer to determine if possible the relative losses of different asphalt paving mixtures from disintegration by water. In what follows, the names of the different varieties of asphaltum tested are not given, because the writer believes the variation in losses to be due to conditions other than the quality of the asphaltum itself; and the publication of the varieties might work an undeserved hardship upon the contractor. The different asphalt mixtures are, therefore, referred to by the name of the city from which the sample was secured.

The first test, which was preliminary, was made on two 5-oz. samples, one of asphalt block, the other of sheet asphalt, both taken from the new Lafayette pavements one month after opening to traffic. The two samples were immersed in water for 15 days; they were then rubbed with the bare fingers until all of the softened material had been removed. The water was then renewed and the ples used in the first experiment varied considerably in the increase of weight, due to water absorbed. After 15 days the asphalt block sample had increased 0.98% in weight, while the sheet asphalt sample had increased 2.40%. The gain in weight was greatest for the first 72 hours, but continued for several days.

A more extended investigation was then begun on samples of pavements that varied widely in character; the results of part of these investigations are shown by the diagrams, Figs. 6, 7 and 8. The samples included two of asphalt block and four of sheet asphalt, all as nearly as possible of the same volume. The samples obtained from any city were, of course, not necessarily characteristic of the pavements of that city, but of a single pavement only. All of the cities mentioned probably include both good and bad examples among their pavements.

The Lafayette asphalt block sample was from an apparently sound block after one month's traffic on South St. It was manufactured in the summer of 1899, being thus about six months old when the investigation began. The Fort Wayne asphalt block was from a block that had been selected from the sample asphalt block intersection at Ft. Wayne, Ind., after seven years of wear. The block

Fig. 2.—Hole in Gutter of Asphalt Pavement on Canal St., Grand Rapids, Mich.
(Pavement laid in 1890.)

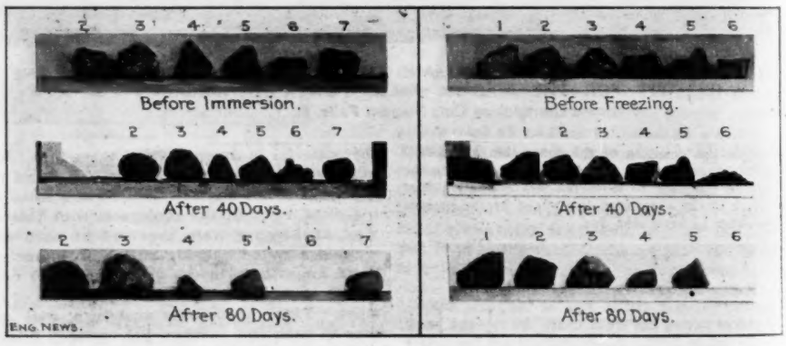

1 2 3 4 5 6 7
Before Immersion.
2 3 4 5 6 7
After 40 Days.
2 3 4 5 6 7
After 80 Days.
ENG. NEWS.
1 2 3 4 5 6
Before Freezing.
1 2 3 4 5 6
After 40 Days.
1 2 3 4 5 6
After 80 Days.

Fig. 9.—Samples Shown in Fig. 6 (Immersion). Fig. 10.—Samples Shown in Fig. 8 (Freezing).

FIGS. 9 AND 10.—VIEWS OF TWO SETS OF TEST SAMPLES AT VARIOUS STAGES.

on the same street. The ends of the straight edge rest upon portions of the pavement that are apparently sound. The defective spot is full of disintegrated asphalt, which extends down to the concrete base. This again was probably caused by the softening effect of water, and accelerated, perhaps, by the stamping of horses hitched at the curb.

Fig. 3 is from Massachusetts Ave., Indianapolis, Ind., a sheet asphalt pavement laid in 1891, and which has required frequent patches to cover similar spots.

No such disintegration has, so far as the writer samples again immersed, and the operation repeated at intervals of 15 days. Before the first immersion, no impression could be made on either sample by the above method of rubbing. The losses were measured in percentage of original weight, and were as follows:

	Days						
	15.	30.	45.	60.	75.	150.	Total
Sheet asphalt	1.9	13.8	24.0	40.3	20.0	...	100.0
Asphalt block	0.1	0.2	1.3	2.3	....	9.3	13.2

The results are shown graphically in Fig. 5, in which the vertical ordinates from the base to the respective curves, represent the percentage of ma- was removed during the summer of 1899. The pavements are excellent ones.

The Detroit sheet asphalt sample was taken from Jefferson Ave., in 1899, after three years' satisfactory service in the pavement. The New York sheet asphalt was from Madison Ave., after five years of wear, and an indefinite time on exhibition, probably a year or two; it was submitted to the City Engineer of Lafayette by one of the competing bidders as a sample of their work. It is to be presumed, therefore, that the pavement was giving satisfactory service; the length of time removed from the pavement might reduce the abil-

ty of the sample to resist water. The Cincinnati sheet asphalt sample was also submitted in a similar way as a representative pavement.

The Indianapolis sheet asphalt was taken from Central Ave., in 1899, after one year of wear in a good pavement. The Grand Rapids sample was from State St., Grand Rapids, Mich., after seven years of traffic. The pavement has become very dry, inelastic, brittle, and has required considerable expense for repairs. Cracks and disintegrated spots are frequent.

The specific gravity, and absorption in five days were determined and are given in the accompanying table. The bitumen was determined by dissolving portions of the samples in carbon bisulphide:

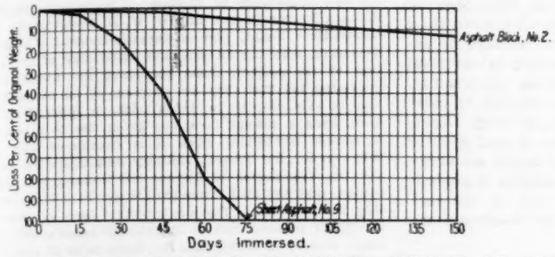


FIG. 5.—PERCENTAGE LOSSES OF ORIGINAL WEIGHT OF SHEET AND BLOCK ASPHALT PAVEMENTS, FROM LAFAYETTE, IND., AFTER VARIOUS PERIODS OF IMMERSION.

(Based on amount of material softened sufficiently to be rubbed off with bare fingers.)

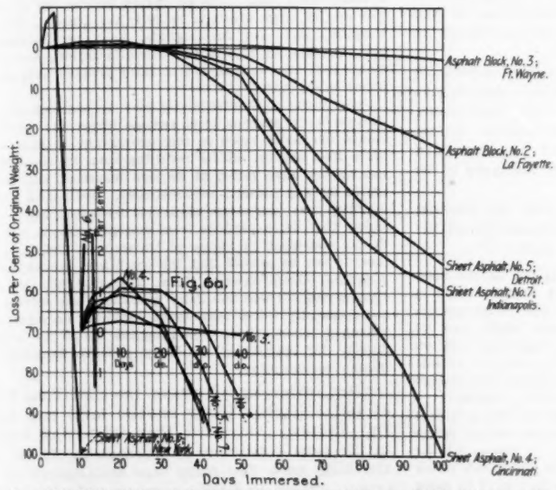

Loss Per Cent of Original Weight.
Asphalt Block, No. 3; Ft. Wayne.
Asphalt Block, No. 2; La Fayette.
Sheet Asphalt, No. 5; Detroit.
Sheet Asphalt, No. 7; Indianapolis.
Sheet Asphalt, No. 4; Cincinnati.
Fig. 6a.
Days Immersed.

FIG. 6.—PERCENTAGE LOSSES OF ORIGINAL BLOCK ASPHALTS OF WEIGHTS OF SHEET AND WIDELY VARYING CHARACTER, AFTER DIFFERENT PERIODS OF IMMERSION.

(Based on amount of soft material removed by wire brush.)

Physical Data of Various Samples of Asphalt.

No.	Name.	Age, yrs.	Weight in ozs.	Specific gravity.	Per cent.—Absorption.	Per cent.—Bitumen.
1.	Brick	2	6¼	2.30	0.90	.....
2.	Lafayette asphalt b'lk.	0½	5	2.25	0.94	6.42
3.	Ft. Wayne " "	8	6¼	2.30	0.52	6.81
4.	Cincinnati sheet asph.	6	4¼	2.11	1.26	.....
5.	Detroit " "	3	4	2.20	0.92	11.40
6.	New York " "	8	3¼	1.83	9.00	6.14
7.	Indianapolis " "	2	4¼	2.12	0.76	9.85
8.	Grnd Rapids " "	8	3	1.92	5.70	7.22
9.	Lafayette " "	0½	5	2.09	2.40	11.21

The two samples of asphalt block and four of sheet asphalt, Nos. 2, 3, 4, 5, 6, 7, were immersed in rain water for ten days; they were then weighed, the affected portion removed with the wire brush, and the sample again weighed to determine the loss. They were then again immersed in fresh rain water for ten days, when the operation was repeated, and so on.

At the end of the first ten days of immersion the New York sheet asphalt No. 6 crushed beneath the fingers, the destruction being complete.

In the diagram, Fig. 6, the losses in per cent. of original weight are plotted downward from the zero line; the vertical ordinates from the base line to the curves thus represent the percentage of original weight remaining after the various ten-day intervals. The diagram shows a remarkable difference between the resistance of sheet asphalt and asphalt block to water. After 20 days of immersion the sheet asphalt losses began to increase rapidly. The Lafayette asphalt block showed marked loss after 40 days of immersion, while the Ft. Wayne asphalt block showed practically no loss, the total in 100 days being but 2½%. For sheet asphalt the total exceeded in every case 50%, and in two out of the four, equalled 100%. The distinction appears marked in the cases shown, but the number of comparisons is too few to prove the loss, as the variations may be caused by numerous conditions. As to the action of water on the two materials, it is, therefore, enough to say that of two samples of asphalt block, one good, the other inferior, and four samples of sheet asphalt, three good and one inferior, the sheet asphalt showed from 4 to 20 times the loss from asphalt block.

The diagram shows besides some interesting characteristics that may be accepted as having more general application. Those samples which increased most in weight from absorption were disintegrated most rapidly (see Fig. 6a). This relation was, perhaps, to be expected; but the diagram seems to show that an absorption test might be a reliable means of comparing different samples of sheet asphalt for the action of water. The tests on asphalt block have thus far been too few to point definitely to a similar conclusion. But it might be expected that different varieties of asphalt block might be thus compared, and tests are now being conducted, thus far with favorable results, to note the accord of this test with actual service. The relation does not apparently hold between asphalt block and sheet asphalt; note that asphalt block with a higher absorption than sheet asphalt suffered less loss.

Sheet asphalt that absorbs more than 1½% of water in 72 hours, apparently disintegrates very rapidly. This must be accepted with one condition, however, the fact that the Lafayette sheet asphalt absorbed 2%, points to the possibility of a new asphalt pavement being more porous than one that has been hardened and compacted by wear. That sample, which was but six months old, was disintegrated with ease. It may be, therefore, that sheet asphalt, although perhaps quite susceptible to the action of water when first laid, gradually gains the ability to resist that action. On the other hand, sheet asphalt dries out, and oxidizes, becoming more porous with age if not compacted by traffic. This would lead to the conclusion, which is abundantly confirmed by actual service, that sheet asphalt attains its maximum resistance to the action of water two or three years after laying, depending upon the amount of traffic. With no traffic it would probably grow more porous from the day of laying. This has been partly confirmed by tests of samples taken from the crown compared with similar samples from the gutter, although the element of time has not yet been included. Traffic is, therefore, essential to the endurance of sheet asphalt, a proposition that is endorsed by the results of actual service.

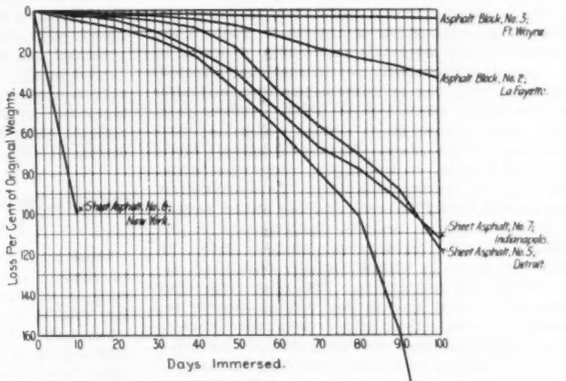

Loss Per Cent of Original Weights.
Asphalt Block, No. 3; Ft. Wayne.
Asphalt Block, No. 2; La Fayette.
Sheet Asphalt, No. 6; New York.
Sheet Asphalt, No. 7; Indianapolis.
Sheet Asphalt, No. 5; Detroit.
Days Immersed.

Fig. 7.

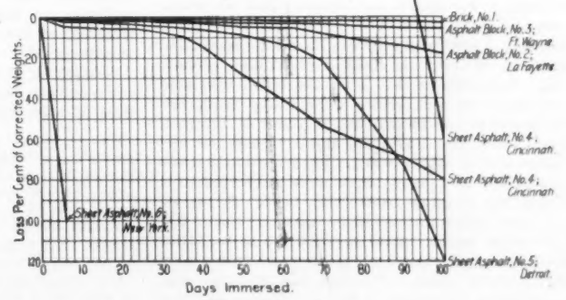

Loss Per Cent of Corrected Weights.
Brick, No. 1
Asphalt Block, No. 3; Ft. Wayne.
Asphalt Block, No. 2; La Fayette.
Sheet Asphalt, No. 4; Cincinnati.
Sheet Asphalt, No. 6; New York.
Sheet Asphalt, No. 5; Detroit.
Days Immersed.

Fig. 8.

FIG. 7.—RESULTS SHOWN IN FIG. 6, RECOMPUTED TO SHOW PERCENTAGES OF LOSSES BY WEIGHTS OF SUCCESSIVE SAMPLES.

FIG. 8.—EFFECT OF FROST ON SHEET AND BLOCK ASPHALT PAVEMENTS.

(Plotted on same basis as Fig. 7.)

A general relation may also be noted between the specific gravity and the rate of loss, although it is not so marked as the relation for absorption values. It is a popular idea that the percentage of bitumen contained determines the ability of the pavement to resist water. This is flatly contradicted by the asphalt block and by the Lafayette sheet asphalt. The true statement of the case seems to be that the drying-out and oxidation of the bitumen and oil produces porosity, which permits disintegration. Considered with respect to the action of water alone, therefore, the pavement with the least amount of bitumen in its original composition would doubtless be the most permanent.

It is not to be assumed from these experiments that asphalt paving mixtures alternately wetted and dried would be acted upon with as great a degree of rapidity. The action in such cases is illustrated by the actual service of the pavement, which, while alternately wet and dry, and subjected to no traffic, may yet endure for years. The value of the above investigation is in showing that constant immersion will do damage; and that cracks and depressions and unprotected gutters,

which remain the surface water, endanger the life of the pavement.

It may be noted that the curves show a slight upward tendency after the loss from the sample has approached 50%; this is due to the fact that the percentages are computed on a constant basis, while the sample presents a decreasing amount of surface to the water, and consequently shows a decreasing loss after passing a certain point. To correctly represent the losses based on the decreasing weight, the curves of Fig. 6 are again shown in Fig. 7, but with the losses now plotted in percentages of the weight of the samples at the time the material was removed. In nearly all cases the curves show a constantly increasing loss. The curves in this diagram are, of course, free from the error of increasing weight due to absorption, and show only the actual percentage of loss for the different intervals.

A parallel test was conducted on six samples immersed in distilled water for 100 days, then allowed to stand without water for 30 days, and without abrasive action of any kind. Refined asphaltum, which absorbed but 0.06% of water in 15 days, was apparently not in the least affected. The same was true of crude asphaltum, although its absorption amounted to 1.80%. Indianapolis sheet asphalt showed a slight softening and crumbling at the edges. Lafayette asphalt block crumbled slightly on the edges, comparing favorably with the Indianapolis sheet. Lafayette sheet asphalt was badly affected and the entire sample crumbled to pieces beneath the pressure of the fingers. Grand Rapids sheet asphalt broke up into small particles without outside assistance, after 40 days of immersion. The most important point to be noted here is that refined asphalt remains hard and elastic after a continued immersion which may cause the complete disintegration of asphalt paving mixtures. The addition of foreign matter evidently gives the water access to the interior structure, accelerating the softening process.

A parallel test was also conducted to determine the effect of frost on sheet asphalt and asphalt block. A sample of No. 1 paving brick was also included. The test pieces were taken from the same parts of the pavements as those of the preceding tests, and gave the same values for absorption within 0.02 or 0.03%. They were immersed in water for four days; then were subjected to a temperature ranging from — 8° to 32° F. for 16 hours, and again immersed in water at about 70° F. for eight hours. This operation was repeated until the samples had been alternately frozen and thawed, three times. The softened material was then removed by means of the wire brush, and the operation repeated. When the temperature for any desired exposure failed to fall below 32° F. the pieces were allowed to remain immersed in the water; each successive removal of disintegrated material was therefore the result of three freezings of 16 hours each, with immersion for the balance of the interval. The losses for the successive intervals, based on the weight during that interval, are plotted in the diagram of Fig. 8. The number of times frozen in each interval is shown by F_3, F_6, etc. The method of comparison and the scale are the same as for Fig. 7, so that samples of the same pavements may be compared on the two diagrams. It is clear that the effect of alternate freezing and thawing was not as great as continual immersion; the samples showed greater change after the freezing became impracticable, and was replaced by continued soaking. The New York sample went to pieces without delay after three days of freezing.

In all of the preceding tests the test pieces were chosen with one face a part of the original surface of the pavement. This face invariably softened first and gave the greatest loss.

Photographs showing the progress of the test of Fig. 6 are shown in Fig. 9, and the test pieces of Fig. 8 are photographed in Fig. 10, together with the wire brush used in removing the decayed material. The first view in each case was taken at the beginning of the test, and the others at intervals of 40 days. The numbers correspond to those of the diagrams and of the table. The comparison of the samples in the photographs should be made with No. 3 as a basis, as it remained practically constant in weight throughout.

The conditions to which pavements are subjected are so varied that it is extremely difficult to reproduce or control them satisfactorily in laboratory experiments, especially with pavements of asphalt, which are in themselves very complex compositions. Deductions from such experiments should, therefore, be verified by the results of actual service. The writer believes from the above experiments, and from his own observation of actual service conditions, that the following conclusions may safely be drawn: Refined asphaltum, as compared with asphalt paving mixtures, shows practically no disintegration by continued immersion in water. The addition of a limited amount of sand to refined asphaltum decreases its resistance to decay; but a paving mixture containing a limited amount of asphaltum, say 10%, may in time become less able to resist disintegration than a mixture containing a smaller percentage of asphaltum. Traffic or frequent rolling is essential to the permanence of sheet asphalt pavements. The action of frost on asphalt pavements, as compared with continued immersion, is very slight, provided the absorption of water is not greater than 1 or 2%. An absorption test might be advisable in choosing from different varieties of asphalt block for pavements. Asphalt block is less susceptible than sheet asphalt to the disintegrating action of standing water.

THE HEALTHFULNESS OF MILK FROM DAIRIES ON ENGLISH SEWAGE FARMS.

Some interesting information regarding dairies on sewage farms, and the healthfulness of the milk so produced, is given in a recent report by Mr. Fred'k W. Andrews, M. D.*

The testimony on the healthfulness of such milk was mainly of a negative character; that is, inquiry failed to show that these milk consumers, of which there are many in some English towns, suffered in health thereby, while the nutritive qualities of the milk are shown by analyses to be relatively high.

Regarding the production of milk at various town sewage farms in England, and the healthfulness of such milk, Dr. Andrews says:

> The production of milk and butter is one of the most profitable, or least unprofitable, of the uses to which a sewage farm can be put. The large crops of Italian rye grass, and of mangold and other roots which can be raised, are, as a rule, far more advantageously used on the spot for the feeding of cattle than sold to outside buyers. Hence most large towns which treat their sewage on the land devote much attention to dairy produce.
>
> Birmingham and Reading may be cited as two instances in which dairy produce from the municipal sewage farms has been extensively sold for 20 years or more. At the Birmingham farm a herd of some 200 shorthorn milch cows is maintained, and I have never seen a herd in more uniformly good health and condition. They are never allowed to pasture on the farm, but are exclusively stall fed. The milk is all sold to a single wholesale dealer in Birmingham. In the year ending March 31, 1897, 188,667 gallons† of milk were sold, in the following year 188,213 gallons, and last year 187,186 gallons. The sum realized by the sale of the milk last year was $22,050. Other produce from the sewage farm is also extensively sold in Birmingham.
>
> Reading maintains a herd of 120 milch cows on the corporation sewage farm. For more than 20 years an average of more than 1,200 gallons of milk weekly has been sold to restaurants and milk dealers in the town, and annual sums varying from $9,100 to $13,300 have been realized by its sale.
>
> As other instances I may cite Croydon, which in 1897 realized $6,800 by the sale of dairy produce from its sewage farm, and Nottingham, which in 1897 sold milk and butter to the value of $11,800, and in 1898 to the value of $11,400. Had time permitted I could doubtless have multiplied statistics, but enough has been said to show that dairy produce from sewage farms has been consumed for many years past on a very large scale in certain towns in England. In other words, if the milk from sewage farms were capable of producing results deleterious to the consumer, it has had at least ample opportunity for the production of such results.
>
> It may be added that the dairy produce from sewage farms seems everywhere to command a ready sale. Even where prejudice has at first existed against it, such prejudice has rapidly died down. As a matter of fact the milk and butter produced are commonly of unusually good quality. Dr. Hill, the Medical Officer of Health of Birmingham, informs me that the milk from the sewage farm there shows an average of over 13% of total solids, and at one time sold for only a little less than 1 ct. per gallon more than any other milk supply in Birmingham.
>
> I have endeavored to ascertain whether any case is on record in which the consumption of milk or butter from a sewage farm has produced disease amongst the consumers by reason of its source. It is plain that milk from a sewage farm is as liable as milk from any other source to subsequent contamination with the germs of disease. The point at issue is whether, or not, it has ever caused disease in virtue of its emanation from a sewage farm. I am entirely unable to find any such case. It is a commonplace of those standard works on hygiene which deal with the subject, that no instance is known in which milk from a sewage farm has produced disease in virtue of its origin. I am not conversant with any such case as the result of my own experience or reading. I have inquired of Sir Richard Thorne-Thorne and Dr. W. H. Power at the Local Government Board, and of Surgeon-General O'Dwyer at Aldershot, who has an extensive knowledge of the literature of the subject: these gentlemen are unanimous in informing me that they are unaware of an authenticated case in this country in which milk, or other dairy produce, from a sewage farm has given rise to disease. It is almost incredible, when it is considered how carefully, under the present sanitary administration of this country, the causes of disease are investigated and recorded, that any such cases should not be well known did they actually exist. There is a further point of view from which the question may be considered—namely, the statistical. Can it be shown that the death rates of such towns as Birmingham and Reading, which have consumed some thousands of pounds worth of sewage-fed dairy produce annually for 20 years, contrast unfavorably with the average death rate? It cannot. From the last report of the Registrar-General I take the following figures as to the average death rates from all causes for the last 10 years. For the 33 large towns it is 20.4; for London, 19.7; for Croydon, 14.4; for Birmingham, 20.7; for Nottingham, 18.5; for Reading it is 15.13. There is nothing here to indicate that the consumption of dairy produce from sewage farms is injurious.
>
> From these considerations it may be asserted that, although dairy produce from sewage farms has been consumed for many years in this country on so extensive a scale that baneful effects resulting from its consumption can hardly have failed to become manifest, such effects are in no way hitherto demonstrated. Neither in any individual case, nor from statistical evidence, has it been shown that dairy produce from sewage farms is injurious to the consumer in virtue of its source. Unless, therefore, it can be proved that the conditions existent on the Aldershot Camp Sewage Farm, and especially the conditions under which the dairy operations are carried out, are materially worse than those obtaining on other well-managed farms, there would appear to be no a priori reason for supposing the dairy produce dangerous for human consumption.
>
> After reviewing at length the conditions found at the Aldershot Camp sewage farm and dairy, Dr. Andrews concluded that there was nothing in the local conditions to warrant the belief that the milk from the farm was endangered by its origin. There had been some prejudice regarding this milk, but that, he thought, was due to a period of bad management of the farm as a whole, while under lease. For a number of years past the farm has been operated for the war office under the direction of Col. Alfred S. Jones, Assoc. M. Inst. C. E. The conditions have been greatly improved by him, and early in 1899 license to sell milk from the farm within the camp was renewed by General Sir Redvers Buller, it having been revoked in 1896.
>
> The Aldershot sewage farm has an area of 125 acres. It receives sewage from the camp only, the population of which in summer has been from 20,000 to 25,000; in winter, less. Although the separate system of sewerage is in use, the average fair weather flow of sewage is given as 1,200,000 gallons a day. After passing through "depositing tanks" the sewage is applied directly to the farm, some three-fourths of the total area of which has been leveled and underdrained. Where not so treated, the land is subject to "ponding." The underdrains are about 33 ft. apart, and from 3 to 4 ft. beneath the surface.
>
> The staple crop is Italian rye grass, besides which osiers, rhubarb, cabbages, mangolds and other roots are raised to a lesser extent. During the past three years, while the sale of milk in the camp was prohibited, only eight cows were kept. Butter was made during this period and sold readily. Dr. Andrews found that the dairy herd had been increased recently to 24 cows, which number was about to be doubled.

*"Report on the Condition of the Aldershot Camp Sewage Farm and of the Dairy Maintained Upon It," made to the Secretary of State for War, May 5, 1899.

†The original English figures have been converted to American equivalents.—Ed.

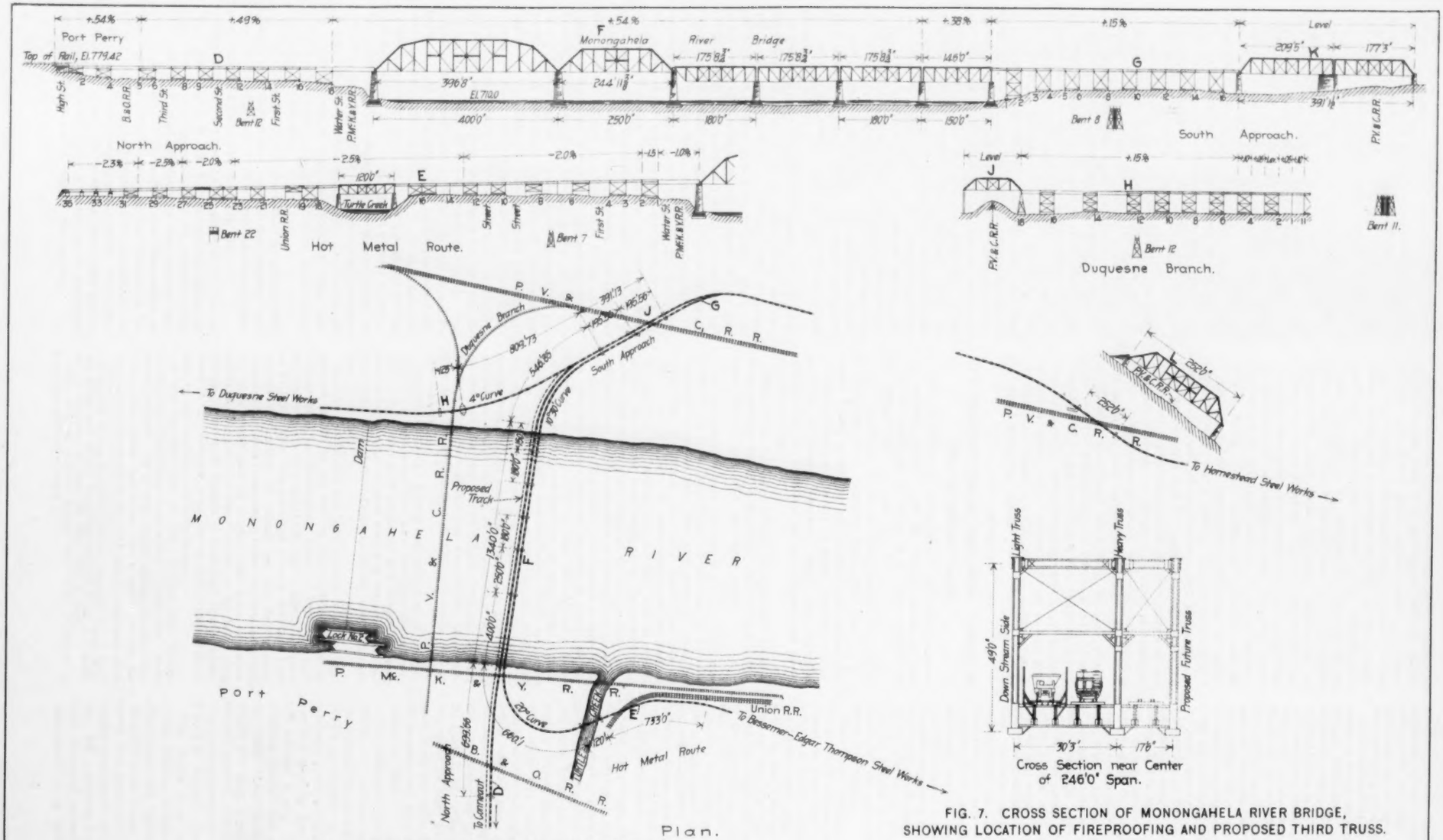
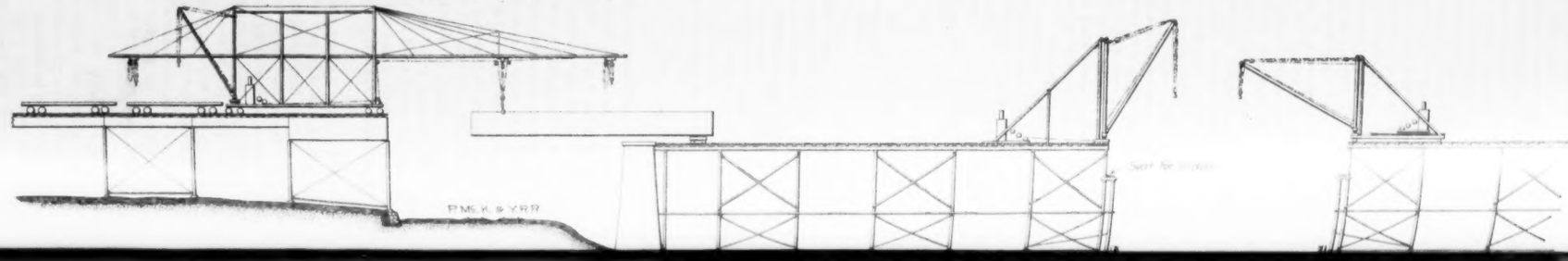


FIG. 5. PLAN AND ELEVATIONS OF MONONGAHELA RIVER BRIDGE AND VIADUCT CONNECTIONS; UNION R. R.

FIG. 7. CROSS SECTION OF MONONGAHELA RIVER BRIDGE, SHOWING LOCATION OF FIREPROOFING AND PROPOSED THIRD TRUSS.

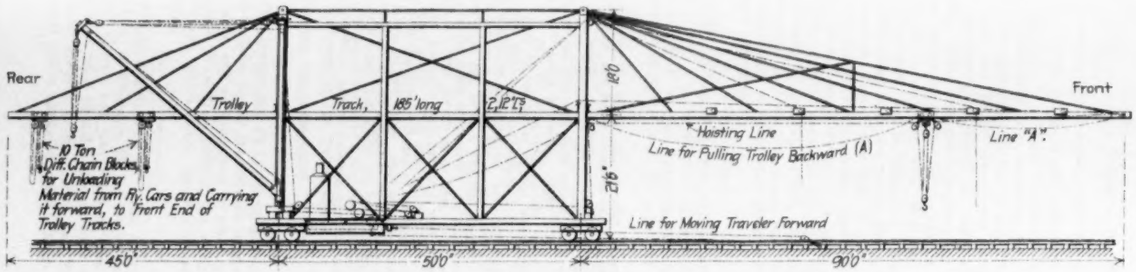


Elevation.

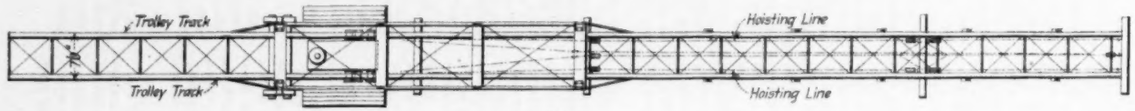
FIG. 8. PLAN AND ELEVATION OF FALSEWORKS FOR CHANNEL SPAN.

Elevation.

FIG. 8. PLAN AND ELEVATION OF FALSEWORKS FOR CHANNEL SPAN, MONONGAHELA RIVER BRIDGE.

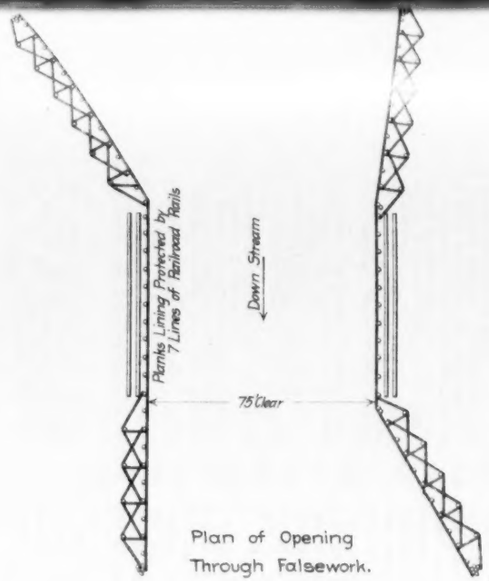


Side Elevation.

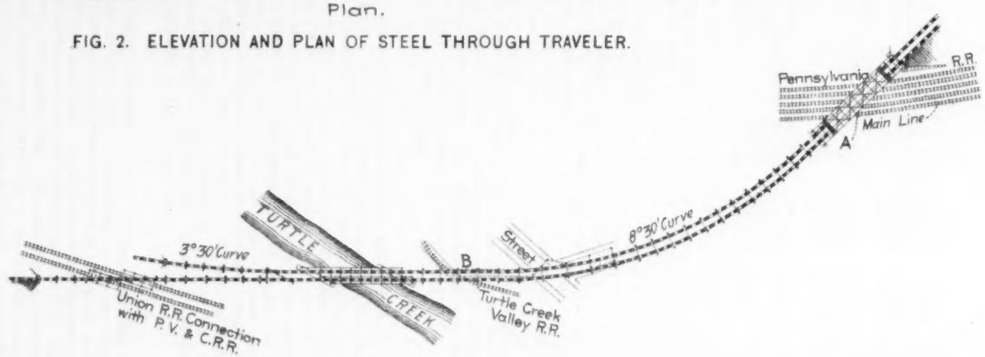


Plan.

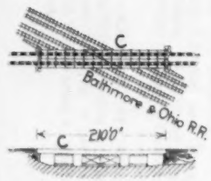
FIG. 2. ELEVATION AND PLAN OF STEEL THROUGH TRAVELER.



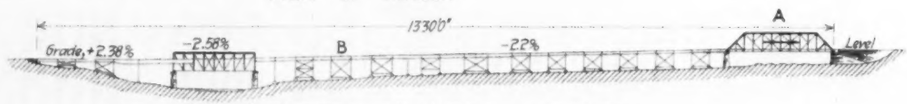
Plan of Opening Through Falsework.



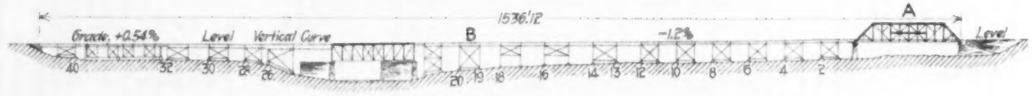
Plan of Viaduct.



Crossing over the B. & O. R. R. near Turtle Creek.



Elevation of Viaduct, Low Track.



Elevation of Viaduct, High Track.

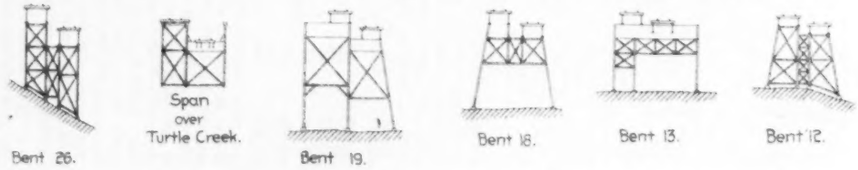


FIG. 4. PLAN AND ELEVATION OF VIADUCT WITH TRACKS AT DIFFERENT LEVELS, UNION R. R.

SPECIAL DETAILS OF

BRIDGE AND VIADUCT WORK;

P., B. & L. E. AND UNION RAILWAYS.

Keystone Bridge Works, Pittsburg, Pa.
Engineers and Builders.

Emil Swensson, M. Am. Soc. C. E.,
Chief Engineer.

CHAS. HART, LITH., 26 VESEY ST., N. Y.